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Operable Unit 3-14 Tank Farm Soil and Groundwater Remedial Investigation/Baseline Risk Assessment

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Operable Unit 3-14 Tank Farm Soil and Groundwater Remedial Investigation/ Baseline Risk Assessment

Lorie S. Cahn
Michael L. Abbott
John F. Keck
Peter Martian
Annette L. Schafer
Michael C. Swenson

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ABSTRACT

A remedial investigation and baseline risk assessment was conducted for Operable Unit (OU) 3-14 tank farm soil and groundwater. OU 3-14 was created to address data gaps that prevented a final remedial action decision for the Idaho Nuclear Technology and Engineering Center (INTEC) tank farm soil and groundwater during the OU 3-13 comprehensive remedial investigation/ feasibility study (DOE/ID-10572). New source terms were developed based on extensive searches of historical records and using process knowledge. New and existing probeholes were gamma-logged, and new cores were collected through the alluvium and analyzed for contaminant concentrations.

Site CPP-31 was caused by a 1972 leak of 18,600 gal of sodium-bearing waste during an unsuccessful transfer of waste between two underground storage tanks. This site accounts for an estimated 87.8% of the source of strontium-90 to groundwater from the tank farm and is the dominant risk driver. An estimated 15,900 Ci of strontium-90 were leaked at this site. The remaining 12% of the strontium-90 source term is from Sites CPP-79 (deep) (4.8%), CPP-27/33 (3.9%), and CPP-28 (3.7%). All other OU 3-14 sites account for less than 0.05%.

Groundwater in the Snake River Plain Aquifer in the vicinity of the INTEC currently exceeds drinking water standards for technetium-99, strontium-90, iodine-129, and nitrate (measured as nitrogen) in one or more monitoring wells. The INTEC groundwater flow and contaminant transport model, which was originally developed for OU 3-13, was revised and updated based on new information. A geochemical model was added to better simulate strontium-90 transport from Site CPP-31. The numerical model predicts that the aquifer will exceed drinking water standards for strontium-90 beyond the year 2095 but not for the other INTEC contaminants.

Results of the recent investigations indicate that soil used as backfill throughout the tank farm is contaminated with cesium-137 and poses an unacceptable risk from external exposure to radiation. The revised baseline risk assessment concludes that the soil inside the tank farm boundary poses an unacceptable risk to current and future workers. The two OU 3-14 sites outside the tank farm boundary (CPP-15 and -58) each pose an unacceptable risk to current workers.

EXECUTIVE SUMMARY

Operable Unit (OU) 3-14 tank farm soil and groundwater is a group of contaminated sites and the underlying groundwater located at the Idaho Nuclear Technology and Engineering Center (INTEC) on the Idaho National Laboratory (INL) Site in southeastern Idaho. This remedial investigation/baseline risk assessment describes the extent of soil contamination from the tank farm, evaluates the resultant risks from exposure to soil and groundwater, and provides the information necessary to evaluate cleanup options. The tank farm is an integral part of the former Chemical Processing Plant (CPP). The CPP (now INTEC) was built in 1951 to dissolve spent nuclear fuel removed from reactors to recover the unused uranium-235. Highly radioactive liquid wastes were stored underground in the tank farm, concentrated, and/or solidified. Although the tanks in the tank farm have not leaked, piping and valves have leaked and contaminated soil, perched water, and groundwater.

A comprehensive remedial investigation and feasibility study was previously completed for OU 3-13, which consisted of all the known contaminated sites at INTEC, including the perched water and groundwater. The Record of Decision for OU 3-13 (a) selected an interim remedy for the tank farm soil and INTEC groundwater; (b) established OU 3-14 to further characterize the tank farm soil and groundwater and coordinate the final remedial action with activities of other programs, which are responsible for treating tank waste and closing the tanks; and (c) selected a final action for the remaining sites, including perched water. Contaminants in the tank farm soil and groundwater are radioactive by-products from reprocessing of spent nuclear fuel.

Because a comprehensive remedial investigation and baseline risk assessment was already completed for the tank farm soil and groundwater under OU 3-13, the OU 3-14 study is a focused investigation designed to address specific data gaps from OU 3-13 that prevented a final decision in the OU 3-13 Record of Decision. This focused study is based upon past information developed under OU 3-13 and includes updated information that has been gathered for the tank farm soil under OU 3-14 and for groundwater and perched water under OU 3-13 remedial actions that were put in place when the Record of Decision was signed in 1999.

Groundwater concentrations currently exceed drinking water standards in the Snake River Plain Aquifer (SRPA) in one or more monitoring wells. The sources of this contamination are primarily from the former injection well (strontium-90 and iodine-129) and from the releases at the tank farm (technetium-99 and nitrate as nitrogen).

Estimates of human health effects associated with the tank farm soil and groundwater are presented in this baseline risk assessment. The OU 3-14 sites are located in an industrial use area and the Agencies have agreed that a future residential use scenario is not considered to be reasonable. A future resident could hypothetically live outside the industrial use area and drill a well into contaminated portions of the aquifer to obtain drinking water.

Cesium-137 in the top 4 ft of soil exceeds risk-based levels for current and future workers. Cesium-137 has a half-life of 30 years, which means that every 30 years, half of the cesium-137 has decayed and only half of it is left. Concentrations of cesium-137 in the soil are very high and will remain well above acceptable levels for hundreds of years.

Numerical modeling is used to predict transport of radioactive contaminants from the release sites to the groundwater and to estimate future concentrations. Modeling predicts that strontium-90 will be above safe drinking water standards in the groundwater in the year 2095 if no action is taken but that the other INTEC contaminants will be below drinking water standards.

The assessment of ecological risk that was previously conducted for the OU 3-13 comprehensive baseline risk assessment was updated. Concentrations of cesium-137 and strontium-90 in the top 10 ft of soil inside the tank farm boundary exceed risk-based levels (hazard quotient of 10).

Regulatory Background

The tank farm soil and groundwater remedial investigation and baseline risk assessment is being developed within the framework of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) as implemented in the Federal Facility Agreement and Consent Order between the U.S. Department of Energy (DOE), the Idaho Department of Environmental Quality, and the U.S. Environmental Protection Agency (the Agencies). The Operable Unit 3-14 tank farm soil and groundwater remedial investigation/feasibility study has unusual regulatory elements because its objective is to select a remedy for a CERCLA site that is co-located within an operating Resource Conservation and Recovery Act (RCRA) facility. It is a focused investigation because a remedial investigation/baseline risk assessment was already completed for these sites. All known release sites within INTEC in 1997 were evaluated in the OU 3-13 Comprehensive Remedial Investigation/Feasibility Study. Ninety-five release sites were evaluated in the remedial investigation, 40 of which exceeded the soil remedial action objectives and were further evaluated for remedial alternatives in the feasibility study. The sites for remedial action were divided into groups and included Tank Farm Soil (Group 1), Perched Water (Group 4), and the Snake River Plain Aquifer (Group 5).

Data gaps and uncertainties associated with contaminant source estimates, the extent of contamination, potential releases from the tank farm soil, and site risk prevented the Agencies from reaching a final remedial decision on the former INTEC injection well, groundwater inside the INTEC security fence, and the tank farm soil. As a result, the Agencies created OU 3-14 to address the final action for tank farm soil and groundwater while interim actions are being implemented under the OU 3-13 Record of Decision, which was signed in October 1999. The interim actions are designed to control the principal threat wastes at the tank farm site due to direct radiation exposure and leaching and transport of contaminants to the perched water and the SRPA. The interim actions will be in place until the final remedy for these sites is selected and implemented as part of the OU 3-14 process. An Explanation of Significant Differences for OU 3-13, which was signed by the Agencies in 2004, transferred the former INTEC injection well and three No Action sites from OU 3-14 back to OU 3-13 and finalized the No Action decision for these sites. Two of the remaining OU 3-14 sites are located adjacent to the tank farm (CPP-15 and CPP-58). The rest of the OU 3-14 sites are located within the tank farm boundary. All of the OU 3-14 sites were consolidated into a single site (CPP-96), which includes (a) all the soil sites and the contaminated backfill between the sites within the tank farm boundary and (b) the two sites outside the tank farm.

The closure of the tanks is being performed in phases in accordance with an Idaho Hazardous Waste Management Act (HWMA)/RCRA closure plan that is prepared for each phase. The final closure of the tank farm will be complete when all of the tanks and ancillary equipment have been closed, including performing any postclosure requirements. A decision to close the unit as a landfill or as a RCRA/HWMA clean closure will be determined during final closure, which is required to be completed by December 31, 2012.

INTEC Background and Operational History

Although none of the tanks in the tank farm have ever leaked, some of the ancillary piping and valves and activities, such as maintenance and sampling, released wastes that contaminated several sites in the tank farm. The waste stored in the INTEC tank farm came from reprocessing spent nuclear fuel and related activities, such as equipment decontamination, uranium purification, laboratory work, off-gas treatment, fuel receipt and storage, and waste solidification. The major sources of tank farm waste were concentrated by-products from the uranium extraction and purification processes and evaporator concentrate. Some of the leaks that contaminated soil were a result of flaws in piping or valve designs. Several major tank farm upgrade projects over the years have improved and replaced inferior designs. The contamination at the OU 3-14 sites occurred between 1954 and 1986. Information on tank farm historical activities is used to determine the volume and composition of the wastes that leaked. Because the tank farm is an operating facility, OU 3-14 activities are integrated with, and limited by, ongoing tank farm closure activities and operations. For example, active waste transfer lines run through the center of the primary OU 3-14 site, and probing and drilling into the soil at this site are constrained.

Environmental Setting and Summary of Subsurface Water Contamination

The INL Site is located in southeastern Idaho and occupies 890 mi^2 (570,000 acres) in the northeastern region of the Snake River Plain. Regionally, the INL Site is nearest to the cities of Idaho Falls and Pocatello and to U.S. Interstate Highways I-15 and I-86. The INL Site extends nearly 63 km (39 mi) from north to south and is about 58 km (36 mi) wide in its broadest southern portion. DOE administers land within the INL Site. Access to the INTEC and tank farm are controlled.

INTEC, which occupies 300 acres, has an established infrastructure. The Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement (DOE/EIS-0287) discusses current land use plans that include a

100-year institutional control period for INTEC. The Agencies have agreed that future residential use within the tank farm boundary (occupying 4 acres) and an industrial use area (12 additional acres) surrounding the tank farm is not a reasonable future use scenario. A permanent barrier system has already been constructed in this area, the tank farm tanks will be cleaned and grouted in place, and other facilities in the area may be difficult to clean up to free-release criteria.

The INL Site is located on the Snake River Plain, which is a large flat valley surrounded by mountains. Air masses crossing this mountain barrier lose most of their moisture before entering the Snake River Plain. Because of this rain shadow effect, the INL Site receives only about 8.6 in. of average annual precipitation, and the region is classified as semiarid.

The United States Geological Survey and DOE have drilled and sampled the INTEC subsurface extensively in an effort to understand and monitor the movement of groundwater and contaminants. To date, over 120 wells have been drilled at and around INTEC. Approximately 47 of these wells were drilled to depths that penetrate into the SRPA; approximately 73 of the wells are completed in the vadose zone to monitor the various perched water bodies beneath INTEC; and numerous holes have been drilled at INTEC in the surficial sediments to the top of the basalt.

The depth to basalt in the tank farm ranges from approximately 40 ft to 60 ft in areas where basalt was removed during construction of the tank farm vaults. Most of the alluvial material in the tank farm area was removed during installation of the underground tank farm and replaced as backfill. The movement of water and contaminants within the tank farm soil is therefore more likely controlled by construction-related layering than any original stratigraphy. Besides the fill materials that were used in the tank farm, the infrastructure (piping, valve boxes, tank vaults, etc.) also controls contaminant movement.

The tank farm alluvium is underlain by thick sequences of basalt flows separated by thin sedimentary interbeds deposited at the land surface during the intervening periods between volcanic eruptions. Infiltrating water from precipitation, the intermittently flowing Big Lost River, and process water have created discontinuous perched water zones. The perched water is contaminated with radionuclides that originated from INTEC activities and from the former INTEC aquifer injection well, which failed and caused contamination in the vadose zone.

The SRPA is approximately 460 ft below the tank farm and is among the nation’s most productive aquifers. It is also contaminated by radionuclides from INTEC activities, including the former injection well and tank farm waste that leaked to the soil and migrated to the aquifer. In 2005, the SRPA beneath INTEC exceeded safe drinking water standards for strontium-90, technetium-99, iodine-129, and nitrate measured as nitrogen in one or more monitoring wells. The strontium-90 contamination is primarily from direct injection of wastewater into the aquifer from the former injection well. OU 3-14 Site CPP-31 is the likely source of the technetium-99 and nitrate contamination.

Perched water and aquifer monitoring at INTEC is being performed under OU 3-13 Group 4 (perched water) and Group 5 (groundwater). A final remedy for perched water and an interim action for groundwater inside the INTEC fence were selected under OU 3-13. Although investigations into the physical and chemical nature and extent of contamination in the perched water and groundwater are not part of the scope of OU 3-14, a final decision for the SRPA will be made under OU 3-14.

Nature and Extent of Soil Contamination

An investigation into the nature and extent of contamination for each OU 3-14 site was performed. An extensive search of historical operational records and reports was conducted and personnel intimately familiar with tank farm operations, history, and process knowledge reviewed these records. A conceptual model of each spill or leak and an estimate of the volume and composition of the contaminated liquid released were developed. Additional probing and soil sampling in the tank farm were performed in 2004 at five sites to resolve identified data gaps. Historical and new soil concentration data were evaluated to support and/or refine the conceptual model of releases at each site. The data are also used to determine exposure concentrations in the soil for use in the risk assessment. Information on the releases was used to develop a reasonably conservative source term with which to calibrate the groundwater fate and transport model and predict future concentrations of contaminants in the aquifer.

Approximately 18,100 curies (Ci) of strontium-90 and 19,100 Ci of cesium-137 are estimated to have been released to OU 3-14 soil. Site CPP-31 is the major release site in the tank farm and accounts for more than 87% of the strontium-90 and cesium-137, 89% of the technetium-99, 20% of the iodine-129, and 90% of the nitrate released at the OU 3-14 sites. Three other sites (CPP-28, CPP-27/33, and CPP-79 [deep]) account for 12% of the strontium-90 and 10.7% of the technetium-99. All other OU 3-14 sites account for less than 0.05% of the strontium-90 and technetium-99. Besides CPP-31, about a quarter of the iodine-129 comes from CPP-79 (deep), a quarter comes from CPP-27/33, and a quarter comes from CPP-28 and CPP-79 (shallow) combined, with less than 3% from all other sites.

Site CPP-31 is the largest site in OU 3-14 and occurred when approximately 18,600 gal of waste leaked during transfer from one tank to another. The liquid (called sodium-bearing waste) was primarily evaporator concentrate and contained approximately 800 mCi/gal of strontium-90. Site CPP-79 (deep) was discovered in 1992 during the 1990s tank farm upgrade project. The contamination at CPP-79 (deep) likely occurred during three waste transfers (one in 1967 and two in 1973) of primarily first-cycle waste from uranium reprocessing. This liquid contained approximately 2,200 mCi/gal. During those transfers, waste leaked from failed flange gaskets in two valve boxes. Some of that waste entered split tile pipe encasements that penetrated the bottoms of the valve boxes. Approximately 400 gal of waste leaked from the tile encasements into the soil in a nearly horizontal portion of the piping located about 30 ft below the surface of the tank farm, causing the CPP-79 (deep) contamination site. During drilling and probing into Site CPP-79 (deep) in

2004, it was determined that the contamination extends vertically to basalt and horizontally under Site CPP-28.

Sampling data collected in 2004 were used along with historical records and photos to determine the extent of contaminated backfill reused in the tank farm. Estimating the amount and location of the contaminated backfill contained within and between the OU 3-14 sites inside the tank farm boundary is not possible due to the lack of complete historical records detailing the location of contaminated backfill and estimates of contamination levels. In addition, some historical excavations used slightly contaminated soil as backfill because the radioactivity levels were undetectable by field instrumentation used at the time and the soil would have been deemed "clean" backfill. Their final location and volumes are unknown. The OU 3-14 investigation determined that contaminated soil from the original OU 3-14 sites was not confined to these site boundaries during major tank farm excavation projects.

Introduction to Risk Assessment and Conceptual Site Model

A conceptual site model has been developed for the OU 3-14 baseline risk assessment to identify the contaminant sources and release mechanisms, exposure pathways, exposure routes, and classes of receptors. Two primary sources exist—the tank farm system and the former injection well. Leaks and spills from the tank farm piping and valves resulted in contaminated soil sources. Human exposures to these contaminants can occur primarily by direct contact with surface soil at the spill sites, or the contaminants can be transported by infiltration of water and subsequent leaching. The primary potential human exposure routes include gamma-emitting radionuclides in the soil (direct exposure) and ingestion of contaminated groundwater. Along with contaminated soil, the former injection well contributes to the groundwater exposure pathway and the groundwater ingestion exposure route. The risks to workers (both current time period and 100 years in the future) and to hypothetical future residents living outside the industrial use area who may drill a well into contaminated groundwater are evaluated.

Soil Risk Assessment

A focused risk assessment for exposure to contaminated soil was conducted because a risk assessment was previously completed under OU 3-13. Because of the mixing of surface soil during tank farm excavation projects, all sampling data were pooled for Soil Inside the Tank Farm Boundary for evaluation of surface soil risk. (These sites, which will be referred to as Soil Inside Tank Farm Boundary, include all OU 3-14 sites [including contaminated backfill in the tank farm] except for the two sites that contain area outside the tank farm boundary, i.e., Sites CPP-15 and CPP-58.) Grouping sites within the tank farm boundary is reasonable because it is improbable that a worker would remain over any single site for the duration of the exposure scenario (40 hours per week, 50 weeks per year, for 25 years). The risk assessment for the other two sites, CPP-15 and CPP-58, which are outside the tank farm, was conducted separately.

The results of the risk assessment are summarized in Table ES-1. Most risk scenarios that were evaluated for surface soil sites were unacceptable due to external exposure to cesium-contaminated soil and exceeded the upper end of the target risk range under CERCLA of 1 in 10,000. The other contaminants and exposure pathways were insignificant contributors to risk (much less than a 1 in 1,000,000 risk of excess cancer).

Table ES-1. Human health contaminants of concern summary (soil).

Site	Contaminant	Risk to Current Worker (2005)	Risk to Future Worker (2095)	Primary Exposure Pathway
Soil Inside Tank Farm Boundary	Cesium-137	**2E-02**	**3E-03**	External exposure
CPP-15	Cesium-137	**7E-04**	8E-05	External exposure
CPP-58	Cesium-137	**4E-04**	5E-05	External exposure

Bold = Exceeds 1E-04 risk-based level.

Groundwater Risk Assessment

Modeling was conducted to simulate release and migration of contaminants from all of the contaminated sites in OU 3-13 and OU 3-14, including the former injection well and to estimate future contaminant concentrations in the SRPA. The numerical code was the same one used in OU 3-13 (the TETRAD simulator). The model was updated with new information, and the subsurface structure was represented using geostatistics, rather than effective interbeds. Model parameters to describe contaminant migration, such as partition coefficients, were defined using site-specific information. Reasonable values from the literature were selected when site-specific data were not available. However, a geochemical model of the alluvium was necessary to account for the release of Sr-90 at Site CPP-31, which also contained high sodium concentrations (called sodium-bearing waste due to the high sodium content in decontamination solutions). The flux of Sr-90 out of the alluvium predicted by the geochemical model was used as input to the TETRAD model. Model calibration to perched water and groundwater monitoring data was difficult because there were insufficient measurements to provide adequate targets for calibration. Contaminants of particular interest for model calibration, such as strontium-90, tritium, technetium-99, and iodine-129, have been monitored sporadically, and the historical record often did not begin until after the contaminant had reached the perched water or aquifer.

The results of the groundwater risk assessment are presented in Table ES-2. The groundwater currently exceeds safe drinking water standards for technetium-99, strontium-90, iodine-129, and nitrate as nitrogen. The groundwater model predicts that strontium-90 concentrations will continue to exceed safe drinking water standards until the year 2129. Strontium-90 was the only contaminant from the INTEC CERCLA sources that was predicted by the model to exceed drinking water standards in the aquifer in 2095 and beyond.

Table ES-2. Human health contaminants of concern summary (groundwater ingestion pathway).

Site	Contaminant	Safe Drinking Water Standard	Maximum Concentration (2095)	Risk to Future Resident (2095)	Year Predicted to be below Safe Drinking Water Standard
All OU 3-13 and 3-14 sites	Tritium (H-3)	20,000 pCi/L	123 pCi/L	1E-07	2001
	Strontium-90	8 pCi/L	**18.6 pCi/L**	2E-05	**2129**
	Technetium-99	900 pCi/L	9.8 pCi/L	6E-07	1999
	Iodine-129	1 pCi/L	0.9 pCi/L	3E-06	2080
	Neptunium-237	15 pCi/L	4.2 pCi/L	5E-06	1987
	Plutonium-239	15 pCi/L	0.002 pCi/L	3E-09	Always
	Plutonium-240	15 pCi/L	0.001 pCi/L	3E-09	Always
	Uranium-234	30 mg/L	2E-07 mg/L	2E-06	Always
	Total risk		3E-05		
	Mercury	0.002 mg/L	0.0001 mg/L	0.01 (hazard quotient)	1993
	Nitrate	10 mg/L	2.1 mg/L	0.04 (hazard quotient)	1998
	Total hazard index			0.05	

Bold = Contaminant predicted to exceed safe drinking water standard beyond 2095.

Summary and Conclusions

The tank farm soil and groundwater remedial investigation and baseline risk assessment is a focused investigation that relies on previous work and fills identified data gaps that remained following the OU 3-13 investigation and that prevented the selection of final remedies for tank farm soil and INTEC groundwater. This report discusses the nature and extent of contamination, provides the results from groundwater modeling and the baseline risk assessment, and forms the basis for remedy selection in the feasibility study. New source terms were developed for all OU 3-14 sites based on extensive historical record searches and process knowledge. Probeholes and coreholes were drilled in five sites in the tank farm to resolve data gaps, and this information was used to verify the conceptual model of the releases. The baseline risk assessment evaluated the impacts of exposure to contaminants in soil and groundwater. The soil risk assessment determined that all OU 3-14 sites pose an unacceptable risk to workers from external exposure to cesium-137 contaminated soil. The groundwater risk assessment predicted that strontium-90 will exceed the safe drinking water limit in 2095.

The model predicts that the residual strontium-90 remaining in Site CPP-31 is relatively immobile and is an insignificant contributor to overall risk to the aquifer. Because of this, remedial action on the contaminated alluvium deeper than 4 ft may not significantly reduce risk. The model predicts that greater than 80% of the strontium-90 has migrated below the alluvium and that the strontium-90 in the perched water and basalts could cause the aquifer to exceed drinking water standards until the year 2129 if no action is taken to reduce perched water migration. The model overpredicts current strontium-90 concentrations in the aquifer near INTEC.

The feasibility study will evaluate remedial alternatives for the top 4 ft of soil over the entire tank farm. For Site CPP-31 (the primary source of strontium-90 contamination in the subsurface, the feasibility study will evaluate alternatives to remediate the soil. Actions to reduce perched water will be considered in conjunction with actions on the soil. The feasibility study will also evaluate remedial alternatives for the SRPA.

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Additional Authors	
Shannon L. Ansley	Geology and data compilation
Arden L. Bailey	Field team leader, work plan
D. Craig Cooper	Geophysics
Chinnathambi Esakkiperumal	Modeling
Jeffrey R. Forbes	Hydrogeology
Lawrence C. Hull	Geochemical modeling
Cynthia E. Klassy	Work plan
Molly K. Leecaster	Geostatistics
Jeffery D. Long	Database
Kenneth R. Manchester	Work plan
George D. Redden	Geophysics
Arthur S. Rood	Groundwater contaminant screening
Susan M. Rush	Cumulative risk assessment
Dean E. Shanklin	Well reports
Lee C. Tuott	Regulatory affairs
Robin L. Van Horn	Ecological risk assessment
Technical Contributors	
Heidi Caye	Model calibration targets
John D. Gilbert	Field team, stratigraphy
Cheryl A. Whitaker	Data retrieval
James D. (Butch) Byrd, Travis K. Barney	Radiological control technicians
Travis Henderson	GeoProbe operator
Tyler L. Winder, Pat Marushia	Samplers
Michael J. Rohe	Hydrologic data
Kristina M. Alberico, John R. Dick	Database
Sample and Analysis Management	
Corey L. Harris	Theron W. McGriff
Donna R. Kirchner	Kathleen A. Otter
Beth A. Mc Ilwain	Susan Shinn
Howard C. Johnson	David N. Thompson

Geographic Information System Staff	
Julie A. Brizzee	Linda A. Tedrow
Daniel D. Mahnami	Luke J. White

Document and Graphic Services	
Michael J. Ingram: technical edit	Linda J. Coleman: text processing

Graphic Design Staff		
Jacalyn M. Brower	Stuart C. Hall	Dianna L. (Dino) Lowrey

Waste Area Group 3 Management		
Martin H. Doornbos	Douglass J. Kuhns	Howard S. Forsythe

CONTENTS

FIGURES

TABLES

ACRONYMS

ALARA	as low as reasonably achievable
APS	Atmospheric Protection System
ARAR	applicable or relevant and appropriate requirement
ARD	Agreement to Resolve Dispute
bgs	below ground surface
BRA	baseline risk assessment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CEC	cation exchange capacity
CFA	Central Facilities Area
COC	contaminant of concern
COPC	contaminant of potential concern
CPP	Chemical Processing Plant
CSM	conceptual site model
CSSF	Calcined Solids Storage Facility
CTS	contaminant transport study
DD&D	deactivation, decontamination, and decommissioning
DEQ	Department of Environmental Quality (Idaho)
DI	deionized
DOE	Department of Energy
DOE Idaho	Department of Energy Idaho Operations Office
DQO	data quality objective
EBSL	ecologically based screening level
ED	exposure duration
EDW	Environmental Data Warehouse
EPA	U.S. Environmental Protection Agency

EPC	exposure point concentration
ERA	ecological risk assessment
ESD	explanation of significant differences
ESRP	Eastern Snake River Plain
FAST	Fluorinel Dissolution Process and Fuel Storage (Facility CPP-666)
FFA/CO	Federal Facility Agreement and Consent Order
FDP	fluorinel dissolution process
FS	feasibility study
FSP	field sampling plan
FY	fiscal year
GRA	general response action
GSF	gamma shielding factor
HASP	health and safety plan
HEAST	Health Effects Assessment Summary Table
HHRA	human health risk assessment
HI	hazard index
HLW	high-level waste
HLW&FD FEIS	Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement
HLWTFU	High Level Waste Tank Farm Upgrade
HP	health physics
HQ	hazard quotient
HWMA	Hazardous Waste Management Act
ICDF	INEEL CERCLA Disposal Facility
ICP	Idaho Cleanup Project
ICPP	Idaho Chemical Processing Plant
ICRP-2	International Commission on Radiological Protection-2

IDW	investigation-derived waste
IDWR	Idaho Department of Water Resources
IEDMS	Integrated Environmental Data Management System
INEEL	Idaho National Engineering and Environmental Laboratory
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
K_d	soil/water partition coefficient
MCL	maximum contaminant level
MCP	management control procedure
MDL	method detection limit
MRDS	monitoring report/decision summary
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NGLW	newly generated liquid waste
NOV	Notice of Violation
NPAT	neutron probe access tube
NPL	National Priorities List
NRTS	National Reactor Testing Station
NWCF	New Waste Calcining Facility (CPP-659)
ORNL	Oak Ridge National Laboratory
OU	operable unit
PBF	Power Burst Facility
PC	potentially complete
PCB	polychlorinated biphenyl
PEW	process equipment waste
PRG	preliminary remediation goal

PSQ	principal study question
QAPjP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
RAL	Radiological Analysis Laboratory
RAO	remedial action objective
RBC	risk-based concentration
RBCA	Risk-Based Corrective Action
RCRA	Resource Conservation and Recovery Act
RD/RA	remedial design/remedial action
RfD	reference dose
RI	remedial investigation
RI/BRA	remedial investigation/baseline risk assessment
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
RTC	Reactor Technology Complex
RWMC	Radioactive Waste Management Complex
SAM	Sample and Analysis Management
SAP	sampling and analysis plan
SBW	sodium-bearing waste
SF	slope factor
SIW	shallow injection well
SNF	spent nuclear fuel
SOW	statement of work
SP	subproject
SRPA	Snake River Plain Aquifer
SVOC	semivolatile organic compound

TAN	Test Area North
TBC	to be considered
TBP	tributyl phosphate
TCLP	toxicity characteristic leaching procedure
TFIA	Tank Farm Interim Action
TLD	thermoluminescent dosimetry
TOS	task order statement
TRA	Test Reactor Area
TRU	transuranic
TRV	toxicity reference value
UCL	upper confidence level
USGS	United States Geological Survey
UTL	upper tolerance limit
VOC	volatile organic compound
WAG	waste area group
WCF	Waste Calcining Facility

Operable Unit 3-14 Tank Farm Soil and Groundwater Remedial Investigation/Baseline Risk Assessment

1. INTRODUCTION

This remedial investigation/baseline risk assessment (RI/BRA) describes the extent of soil contamination from the Idaho Nuclear Technology and Engineering Center (INTEC) tank farm, evaluates the resultant risks from exposure to the soil and to groundwater, and provides the information necessary to evaluate cleanup options. The remedial investigation/feasibility study (FS) is being conducted pursuant to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) under a Federal Facility Agreement/Consent Order (DOE-ID 1991) between the U.S. Department of Energy Idaho Operations Office (DOE Idaho), U.S. Environmental Protection Agency (EPA) Region 10, and Idaho Department of Environmental Quality (DEQ) (collectively known as the Agencies). The INTEC tank farm soil and groundwater are Operable Unit (OU) 3-14 in Waste Area Group 3 (WAG 3).

The tank farm is an integral part of the former Chemical Processing Plant (CPP) located on the Idaho National Laboratory (INL) Site (see Figures 1-1 and 1-2).[a] The CPP was built in 1951 to dissolve spent nuclear fuel (SNF) removed from reactors to recover the unused uranium-235 (U-235) for use in the development of nuclear submarines and in defense programs. The CPP's primary missions were research and recycling nuclear fuel for the Navy. The CPP reprocessed more than 100 types of fuel, each in a different campaign. The fuel came from Navy ships, reactors on the INL Site, commercial reactors, and university and test reactors located throughout the world (Stacy 2000).

At the CPP, highly radioactive liquid wastes were stored underground in the tank farm, concentrated, and/or solidified. The acidic liquids were stored in tanks made of stainless steel. All of the high-level waste in the tanks has been solidified, and the waste that remains in the tanks today is called sodium-bearing waste.

In 1992, following the dissolution of the Union of Soviet Socialist Republics, and the end of the Cold War, the U.S. Government decided to discontinue reprocessing SNF at the CPP, and the priority shifted to cleanup of the legacy wastes from the Cold War. Subsequently, the facility was renamed INTEC to reflect its changed mission. Although the tanks in the tank farm at INTEC have not leaked, piping and valves have leaked and contaminated soil, perched water, and groundwater. A comprehensive RI/FS was previously completed for OU 3-13, which consisted of all the known CERCLA release sites at INTEC (DOE-ID 1997a and 1997b). The Record of Decision (ROD) for OU 3-13 (a) selected an interim remedy for the tank farm soil and INTEC groundwater and (b) established OU 3-14 to further characterize the tank farm soil and groundwater and coordinate the final remedial action with activities of other programs that are responsible for treating tank waste and closing the tanks. Table 1-1 lists the OU 3-14 sites and contains a brief description of each. The regulatory background associated with these sites is presented in Section 2.

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a. Beginning February 1, 2005, the name of the Idaho National Engineering and Environmental Laboratory (INEEL) was changed to Idaho National Laboratory (INL) Site. The Idaho Cleanup Project (ICP) is the name of the project that is performing remediation work at the Idaho National Laboratory Site.

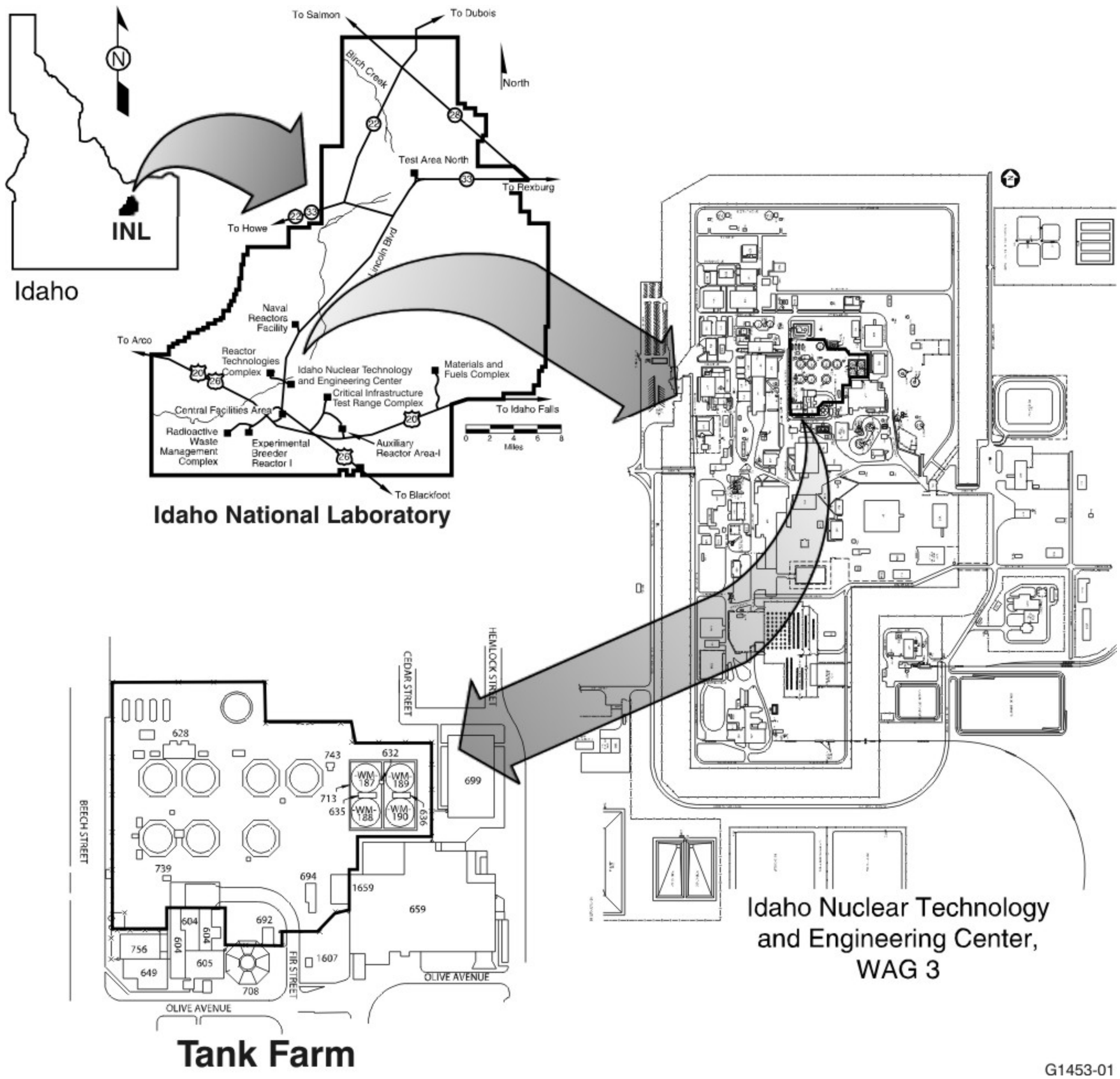

Figure 1-1. Location of the INL, INTEC, and the tank farm.

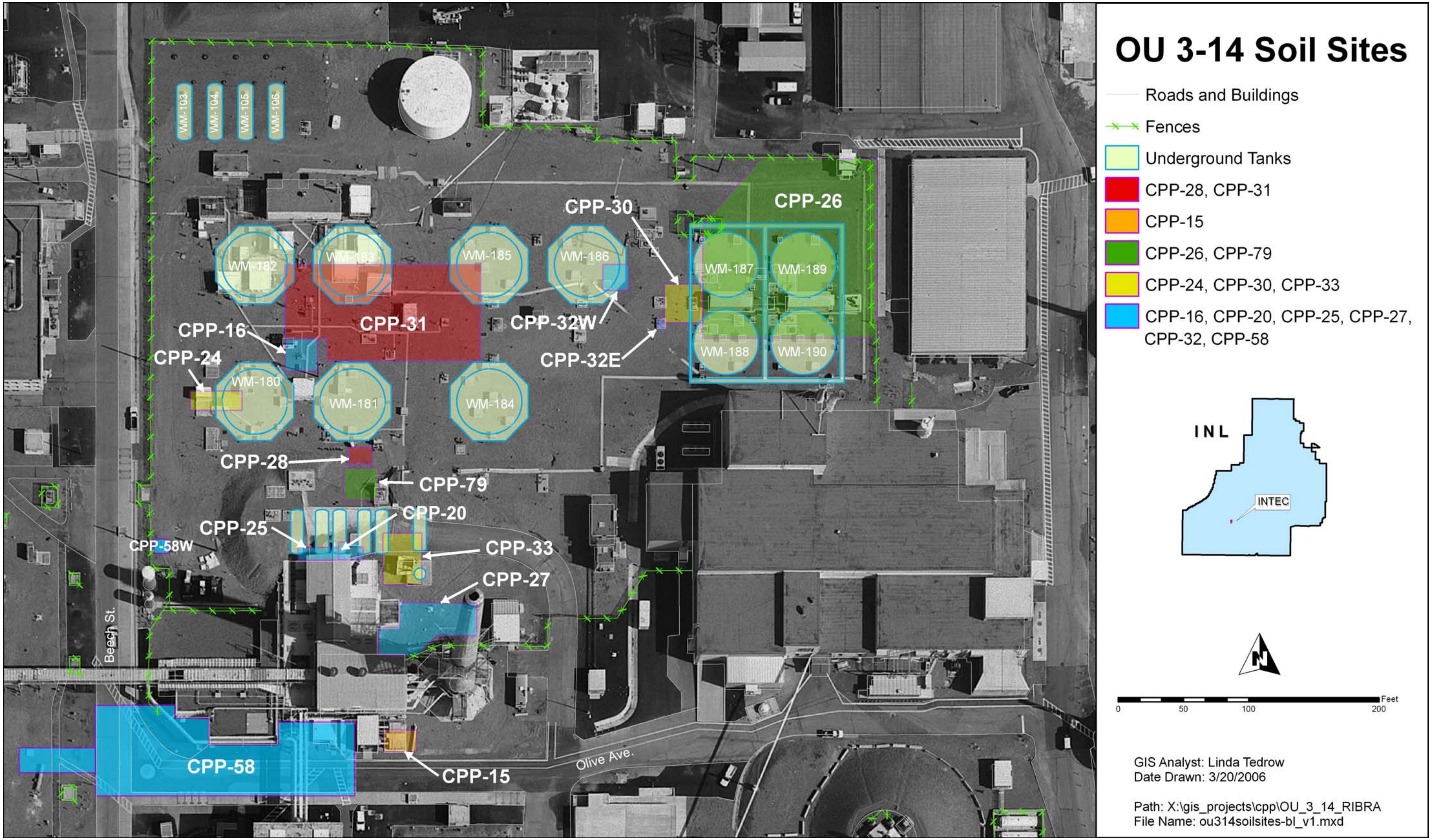

Figure 1-2. Tank farm soil CERCLA sites.

Table 1-1. OU 3-14 CPP release sites description and regulatory history.

Site	Original Operable Unit	Description	Site Group	OU 3-13 ROD Decision
CPP-15	OU 3-08	Solvent burner east of CPP-605	1	Remedial design/ remedial action (RD/RA)
CPP-16	OU 3-07	Contaminated soil from leak in line from CPP WM-181 to process equipment waste evaporator (PEW) evaporator	1	RD/RA-OU 3-14[a]
CPP-20	OU 3-07	CPP-604 radioactive waste unloading area	1	RD/RA
CPP-24	OU 3-07	CPP tank farm area bucket spill	1	RD/RA-OU 3-14[a]
CPP-25	OU 3-07	Contaminated soil in the tank farm area north of CPP-604	1	RD/RA
CPP-26	OU 3-07	Contaminated soil in the tank farm area from steam flushing	1	RD/RA
CPP-27	OU 3-08	Contaminated soil in the tank farm area east of CPP-604	1	RD/RA
CPP-28	OU 3-07	Contaminated soil in the tank farm area south of WM-181 by Valve Box A-6	1	RD/RA
CPP-30	OU 3-07	Contaminated soil in the tank farm area near Valve Box B-9	1	RD/RA-OU 3-14[a]
CPP-31	OU 3-07	Contaminated soil in the tank farm area south of Tank WM-183	1	RD/RA
CPP-32	OU 3-07	Contaminated soil in the tank farm area southwest and northwest of Valve Box B-4	1	RD/RA
CPP-33	OU 3-06	Contaminated soil in the tank farm area near WL-102, northeast of CPP-604	1	RD/RA
CPP-58	OU 3-11	CPP PEW evaporator overhead pipeline spills	1	RD/RA
CPP-79	OU 3-07	Tank farm release near Valve Box A-2	1	RD/RA
CPP-96	OU 3-13	Tank farm interstitial soil	1	RD/RA

a. No Action sites within the tank farm are consolidated into Site CPP-96. Because the sites are within the tank farm they will be subject to the Group 1 Interim Action and to the OU 3-14 RI/FS.

1.1 Purpose and Scope

The primary purpose of the OU 3-14 RI/FS is to support evaluation of final remedies for the tank farm soil and Snake River Plain Aquifer (SRPA). The ROD for the Comprehensive RI/FS for INTEC (OU 3-13) selected an interim action to address contamination in the tank farm soil and the SRPA and deferred the final decision to OU 3-14 (DOE-ID 1999). Because an RI/FS was already completed for the tank farm soil and groundwater under OU 3-13, the OU 3-14 RI/FS is a focused investigation designed to address specific data gaps from the OU 3-13 RI/FS that prevented a final decision in the OU 3-13 ROD.

The RI/BRA is the first part of the RI/FS. Specific objectives of the OU 3-14 RI/BRA and FS follow. The FS objectives are included because they show the end use of the data that are being collected for the RI/BRA:

- Determine nature and extent of contamination—The extent, distribution, and composition of contamination at known release sites from the liquid waste transfer system in the INTEC tank farm will be determined. The tank farm soil from the known release sites between the ground surface and basalt (approximately 45 ft deep) will be characterized as necessary to help define the type and extent of contamination to support the RI/FS tasks. The amount of contaminated material remaining from numerous excavations of tank farm soil that have occurred over the past 30 years will be estimated.

- Evaluate risks to human health from exposure to radioactively contaminated soil—Baseline risks will be quantitatively evaluated for external exposure to an occupational worker from radioactively contaminated tank farm soil, which includes contaminated soil and backfill inside the tank farm boundary and two sites adjacent to the tank farm just outside the southern boundary. Three separate risk assessments were performed: one for soil and contaminated backfill inside the tank farm boundary (Soil Inside Tank Boundary, which does not include CPP-15 and CPP-58) and two for adjacent sites (CPP-15 and CPP-58). The OU 3-13 BRA (DOE-ID 1997a) estimated that the excess cancer risk to occupational workers exposed to tank farm soil is much greater than 1 in 10,000 and that the risk from all other surface pathways is less than 1 in 1,000,000. Because direct exposure to soil contaminated with Cs-137 exceeds risk-based levels and the risks from all other surface exposure pathways were acceptable, the OU 3-14 RI/BRA is not reassessing risk from these other surface pathways.

- Update the INTEC fate and transport model to determine if maximum contaminant levels (MCLs) will be met in the SRPA—The primary human health threat posed by contaminated SRPA groundwater was determined in the OU 3-13 RI/BRA (DOE-ID 1997a) to be exposure to radionuclides via ingestion by future groundwater users. The baseline risk to groundwater from releases to the tank farm soil will be reevaluated in the OU 3-14 RI/FS to reduce the uncertainty of release estimates to the SRPA from the tank farm sources. Specific objectives are to

  - Develop better OU 3-14 contaminant source terms based on process knowledge

  - Incorporate new information from additional perched water and groundwater investigations conducted as part of the remedial actions

  - Develop a geostatistical representation of the INTEC subsurface based on stratigraphic data for use in the INTEC unsaturated zone and aquifer models

  - Incorporate all OU 3-13 and 3-14 sources in the INTEC model to predict concentrations over time in the SRPA to support a final remedy decision for groundwater

  - Establish soil/water partition coefficients (K_ds) for contaminants of concern (COCs) at the tank farm for use in the INTEC fate and transport model.

- Provide a basis for selecting a final remedy for the SRPA—An objective of the RI/BRA is to provide sufficient information for the Agencies to determine whether the interim action selected in the OU 3-13 ROD for the SRPA is sufficiently protective to become the final action or whether a different remedy is appropriate. The effects of potential remedial actions for the tank farm soil on groundwater will be evaluated in the FS using the updated model to aid in selecting a final remedy for groundwater. No additional data gaps in the SRPA—beyond the data being collected under OU 3-13 remedial action—were identified in the OU 3-13 ROD that would prevent selection of a final remedy for the SRPA. The OU 3-13 ROD selected a final action for groundwater outside the INTEC security fence and an interim action for groundwater inside the INTEC security fence. Because the OU 3-13 groundwater remedy includes an interim action, the entire remedy is considered an interim action and the final decision was deferred to OU 3-14. The INTEC groundwater model predicts concentrations over time for the SRPA both inside and outside the INTEC fence. The OU 3-14 ROD will select a final action for INTEC groundwater both inside and outside the INTEC fence. The final action for groundwater in OU 3-14 will supersede the interim action selected in the OU 3-13 ROD.

- Support remedy selection for the tank farm soil—Because the total risk from surface exposure to tank farm soil was unacceptable in the OU 3-13 BRA, the OU 3-14 RI/FS is focused on evaluating remedial action alternatives for contaminated tank farm soil in the FS, rather than on collecting data to reassess the risk from exposure to soil at the tank farm surface. The risk to humans exposed to contaminated soil at the ground surface is dominated by direct exposure to Cs-137, a gamma-emitting radionuclide, and the FS will evaluate remedies that are protective of workers implementing the remedy as well as future workers. As part of the OU 3-14 project, data were collected that will be required in order to mitigate high radiation fields during excavation, treatment, storage, and disposal. Soil characterization data were collected as part of the OU 3-14 project to define waste types that may be generated for treatment, storage, or disposal during future remediation and waste management activities. Excess soil was archived for use in potential distribution coefficient (K_d) and/or treatability studies.

- Coordinate the OU 3-14 tank farm soil remedy with the Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement (HLW&FD FEIS) and Resource Conservation and Recovery Act (RCRA) tank closures—In the OU 3-13 ROD (DOE-ID 1999), the final remedy for the tank farm soil release sites was deferred to OU 3-14, pending further characterization and coordination of any proposed remedial actions with the HLW&FD FEIS (DOE 2002). Information from other tank farm sources (e.g., tanks, piping, sand pads) will be included in remedy evaluation in the FS so that the final remedies considered for tank farm soil will be compatible with anticipated RCRA closure of the tanks. As identified in the OU 3-14 RI/FS Work Plan (DOE-ID 2004), these other sources are not included in the RI/BRA because they are not CERCLA sites, but their contribution to overall risk will be assessed in the FS model to ensure that the cumulative risk from residual sources following final action is acceptable.

- Interface with other tank farm activities, such as deactivation, decontamination, and decommissioning (DD&D); tank farm interim action (TFIA); and perched water and SRPA investigations—Many activities will be ongoing concurrently in the vicinity of the tank farm over the next decade and have the potential to interfere with each other. OU 3-14 will be cognizant of these other activities so that they can be coordinated and interferences can be minimized.

- Perched water remedy is not part of OU 3-14—The OU 3-13 ROD selected a final remedy for Group 4 perched water; therefore, it is assumed that OU 3-14 does not need to consider any further remedial action alternatives for the perched water. If the modeling indicates that the perched water remedy is not protective, the model can be used by Group 4, and it is assumed that modifications to the remedy will be addressed under Group 4 of the OU 3-13 ROD and coordinated closely with actions on contaminated alluvium and the SRPA under OU 3-14.

1.2 Changes from OU 3-14 Work Plan

The following are changes from the OU 3-14 RI/FS Work Plan (DOE-ID 2004):

- Source terms for each OU 3-14 site have been reevaluated – The source terms from each OU 3-14 site were reevaluated based on process knowledge.

- Additional field data were collected to support source term development – Additional field data beyond that specified in the OU 3-14 RI/FS Work Plan were analyzed to support the development of source terms. Some samples were analyzed for Pu-241, zirconium, and fluoride to aid in fingerprinting Site CPP-79 (deep).

- The nature and extent of OU 3-14 sites have been reevaluated – The OU 3-14 RI/FS Work Plan attempted to place an upper bound on the nature and extent of contamination to determine whether data gaps existed for the site and whether more data were necessary from each site. The OU 3-14 RI/BRA more realistically estimates the nature and extent of contamination to facilitate the development of the FS, which must estimate the cost of cleanup within -30 to +50%.

- Group risk is being evaluated - The OU 3-14 sites inside the tank farm, including the interstitial soil, were evaluated as a group when calculating risk from direct exposure, rather than as individual sites. The field data collected under the OU 3-14 RI/FS Work Plan provided evidence that individual sites had been backfilled with contaminated alluvium and the contamination from the original sites has been spread outside the original spill/leak areas. It is also not realistic to assume that a worker would spend 25 years working at an individual site on the tank farm, some of which are less than 20 ft in length.

- Some OU 3-13 source terms were reevaluated - The source terms for a few OU 3-13 INTEC sites that are not OU 3-14 sites were reevaluated to include better source term information.

- A geochemical model was used in evaluation - A geochemical model was used to evaluate the release at Site CPP-31 in conjunction with the flow and transport model to account for the cation competition between the major contaminant, Sr-90, the sodium in the leaked waste, and the naturally occurring calcium.

- The FS will address remedies for SRPA groundwater both inside and outside the INTEC fence – An assumption was made in the OU 3-14 RI/FS Work Plan that the OU 3-14 FS would only address groundwater inside the INTEC fence. However, because the contaminants that are predicted to pose a risk to groundwater are different from those predicted to pose risks in the OU 3-13 RI/FS, the OU 3-14 FS will address the final remedy for groundwater both inside and outside the INTEC fence.

- The OU 3-13 Ecological Risk Assessment was evaluated – This risk assessment was evaluated to determine if it was adequate for OU 3-14.

1.3 Organization of the Document

This Remedial Investigation/Baseline Risk Assessment document for OU 3-14 tank farm soil and groundwater is organized in nine sections supported by 10 appendixes. Brief descriptions of each are given below:

Section 1, Introduction, summarizes the purpose and scope, gives how the document differs from the Work Plan, and presents the organization of the document.

Section 2, Regulatory Background, discusses the unusual regulatory elements of the OU 3-14 RI/FS, including CERCLA and the Tank Farm Facility.

Section 3, INTEC Background and Operational History, discusses INTEC's background, mission, and operational history as they pertain to the Tank Farm Facility, including the tank farm soil contamination sites, sources and compositions of the tank farm waste, and the physical configuration of the tank farm.

Section 4, Environmental Setting and Summary of Subsurface Water Contamination, includes discussions of demography near the INL Site (INTEC); current and projected future land use for the INL Site and INTEC; pertinent surface features of INTEC; current state of knowledge of Eastern Snake River Plain (ESRP) and INL Site regional geology; and meteorology, surface water, perched water, and groundwater hydrology of the INL Site, with particular emphasis on the INTEC area.

Section 5, Nature and Extent of Soil Contamination, details this information at each tank farm release site, describes the conceptual model of each release, summarizes results from previous field investigations, and presents results from the OU 3-14 tank farm soil investigation in 2004.

Section 6, Introduction to Risk Assessment and Conceptual Site Model, provides an introduction to the conceptual site model for the risk assessment and the risk assessment analytical process.

Section 7, Soil Risk Assessment, evaluates adverse impacts on human health resulting from exposure to contaminated surface soil in OU 3-14. It includes the methodology used and results from an assessment of risk from direct exposure to radionuclides in OU 3-14 surface soil. The ecological risk assessment portion reassesses data from the 1997 ecological risk assessment performed in the OU 3-13 RI/FS based on the availability of new sampling data and updated input parameters and toxicity data as documented in an OU 10-04 (INL Sitewide) Comprehensive RI/FS for ecological receptors (DOE-ID 2001). This reassessment was to ensure that the conclusions made in the OU 3-13 RI/FS are still valid.

Section 8, Groundwater Risk Assessment, includes a discussion of the models and methodology used to predict future groundwater concentrations and an assessment of risk to a hypothetical future resident living outside the industrial use area from ingestion of contaminated groundwater.

Section 9, Summary and Conclusions, summarizes the information in this RI/BRA, which forms the basis for the OU 3-14 Tank Farm Soil and Groundwater FS, a companion document to the BRA. It includes the remedial investigation objectives, summaries of the human health and ecological risk assessments, a discussion of applicable or relevant and appropriate requirements, recommended remedial action objectives, and conclusions.

Appendix A, Groundwater Risk Pathway Model Development, Calibration, and Predictive Results, documents the OU 3-14 conceptual and numerical model, which is used as the basis for predicting groundwater contaminant concentrations resulting from previous OU 3-14 releases.

Appendix B, Estimation of Net Infiltration at the Idaho Nuclear Technology and Engineering Center Tank Farm, simulates the vadose zone water balance at several locations within the tank farm soil and provides estimates of the net infiltration rate through the tank farm soil.

Appendix C, Geostatistical Modeling of Subsurface Characteristics in the Area of the Idaho Nuclear Technology and Engineering Center, integrates geological and hydrological data with geostatistical methods to predict subsurface characteristics and improves upon previous efforts in both data completeness and modeling rigor. It discusses the data sets, data assessment, semivariogram calculation and modeling, kriging models, model assessment, and prediction uncertainty.

Appendix D, Estimation of K_d Values for INTEC Groundwater Model, presents a process for estimating K_d parameters from accessible reported data that acknowledges critical assumptions that are inherent in the K_d concept, summarizes maximum and minimum K_d values for the isotopes observed under experimental conditions assumed for the subsurface at INTEC, and gives recommendations for K_d values as an aid for transport model simulations.

Appendix E, Source Terms, comprises correspondence and analyses documenting sources by site for INTEC.

Appendix F, End of Well Reports for the OU 3-14 2004 Tank Farm Soil Investigation at the Idaho Nuclear Technology and Engineering Center, documents the field installation of 23 boreholes and probeholes for subsurface characterization and sampling purposes within OU 3-14, and includes results of gamma logging of existing and new probeholes.

Appendix G, 2004 Laboratory Data Tables, comprises 56 tables giving results of laboratory analysis for field samples collected in OU 3-14 sites in 2004.

Appendix H, Quality Assurance/Quality Control and Data Issues, discusses the sampling and analytical effort for the second phase of the characterization of the tank farm soil, including a quality assurance and quality control (QA/QC) evaluation of the data.

Appendix I, Soil Sampling Data Tables for Risk Assessment, summarizes the soil data and groupings used for human health and ecological risk assessment for OU 3-14 sites and includes Soil inside the Tank Farm Boundary, Site CPP-15, and Site CPP-58.

Appendix J, Evaluation of Sr-90: Hydrogeochemical Simulation of the CPP-31 Release from the Alluvium, Inclusion of Other Sources, Sensitivity, and Implications, presents the methodology and results from the geochemical modeling of the largest release site (CPP-31). It discusses the cation competition between the major contaminant (Sr-90), the sodium in the leaked waste, and the naturally occurring calcium.

1.4 References

DOE, 2002, *Idaho High-Level Waste & Facilities Disposition Final Environmental Impact Statement*, DOE/EIS-0287, U.S. Department of Energy, September 2002.

DOE-ID, 1991, *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory and Action Plan,* Administrative Record No. 1088-06-29-120, U.S. Department of Energy Idaho Operations Office; U.S. Environmental Protection Agency, Region 10; Idaho Department of Health and Welfare.

DOE-ID, 1997a, *Comprehensive RI/FS for the Idaho Chemical Processing Plant OU 3-13 at the INEEL-Part A, RI/BRA Report (Final),* DOE/ID-10534, U.S. Department of Energy Idaho Operations Office, November 1997.

DOE-ID, 1997b, *Comprehensive RI/FS for the Idaho Chemical Processing Plant OU 3-13 at the INEEL-Part B, FS Report (Final)*, DOE/ID-10572, U.S. Department of Energy Idaho Operations Office, November 1997.

DOE-ID, 1999, *Final Record of Decision, Idaho Nuclear Technology and Engineering Center, Operable Unit 3-13, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho,* DOE/ID-10660, Rev. 0, U.S. Environmental Protection Agency, Idaho Department of Environmental Quality, U.S. Department of Energy Idaho Operations Office, October 1999.

DOE-ID, 2001, *Comprehensive Remedial Investigation/Feasibility Study for Waste Area Groups 6 and 10 Operable Unit 10-04*, DOE/ID-10807, Rev. 0, U.S. Department of Energy Idaho Operations Office, August 2001.

DOE-ID, 2004, *Operable Unit 3-14 Tank Farm Soil and Groundwater Remedial Investigation/Feasibility Study Work Plan,* DOE/ID-10676, Rev. 1, U.S. Department of Energy Idaho Operations Office, June 2004.

Stacy, Susan, 2000, *Proving the Principle: A History of the Idaho National Engineering and Environmental Laboratory 1949-1999*, DOE/ID-10799, U.S. Department of Energy Idaho Operations Office, October 2000.

2. REGULATORY BACKGROUND

The Operable Unit (OU) 3-14 tank farm soils and groundwater remedial investigation/feasibility study (RI/FS) has unusual regulatory elements because its objective is to select a remedy for a CERCLA site that is co-located within an operating RCRA facility. In addition, OU 3-14 was created by the OU 3-13 Comprehensive Record of Decision (ROD) for INTEC and is therefore a focused RI/FS to (a) resolve data gaps that remained after the OU 3-13 RI/FS process was completed regarding the tank farm soils and groundwater and (b) select a final remedy to supersede the interim remedies that were implemented under OU 3-13. The regulatory background for the INTEC tank farm is summarized below and includes a discussion of CERCLA, OU 3-13, and RCRA.

2.1 Comprehensive Environmental Response, Compensation and Liability Act Regulatory Background

On July 14, 1989, the INL Site was proposed for listing on the EPA National Priorities List (NPL) (54 FR 48184) using Hazard Ranking System procedures found in the "National Oil and Hazardous Substances Pollution Contingency Plan" (NCP) (40 CFR 300). The INL Site was subsequently placed on the NPL and became subject to the provisions of CERCLA (42 USC § 9601 et seq.) on November 15, 1989. Contaminated sites at INTEC contributed to listing the INL Site on the NPL. DOE Idaho, EPA Region 10, and DEQ (i.e., collectively known as the Agencies) signed a Federal Facility Agreement and Consent Order (FFA/CO) and Action Plan (DOE-ID 1991) for CERCLA cleanups and RCRA corrective actions on the INL Site. The FFA/CO divided the INL Site into 10 waste area groups (WAGs). INTEC was designated as WAG 3. WAG 3 was originally divided into 13 OUs. The locations of the INL, INTEC, WAG 3, and the tank farm soil sites are shown on Figures 1-1 and 1-2.

The goals of the FFA/CO are to ensure that (1) potential or actual INL releases of contaminants to the environment are thoroughly investigated in accordance with the NCP and (2) appropriate response actions are taken to protect human health and the environment. The FFA/CO established the procedural framework and schedule for developing, prioritizing, implementing, and monitoring response actions at the INL Site in accordance with CERCLA and RCRA (42 USC § 6901 et seq.) legislation and the Idaho Hazardous Waste Management Act (HWMA) (IC § 39-4401).

The Secretary of Energy's policy statement (DOE 1994) on the National Environmental Policy Act (NEPA) (42 USC § 4321 et seq.) stipulates that DOE will rely on the CERCLA process for review of actions to be taken under CERCLA and to address the environmental aspects of CERCLA projects. The policy statement also requires that DOE address NEPA aspects and public involvement procedures by incorporating NEPA requirements, to the extent practical, in documents and public involvement activities generated under CERCLA.

2.1.1 Operable Unit 3-13

The FFA/CO designated the comprehensive RI/FS for INTEC (WAG 3) as OU 3-13. All known release sites within INTEC in 1997 were evaluated in the OU 3-13 Comprehensive RI/FS (DOE-ID 1997a, 1997b). Ninety-five release sites were evaluated in the RI (DOE-ID 1997a), 40 of which exceeded the soil remedial action objectives and were further evaluated for remedial alternatives in the FS (DOE-ID 1997b). The sites for remedial action were divided into groups:

- Group 1: Tank Farm Soils
- Group 2: Soils Under Buildings and Structures

- Group 3: Other Surface Soils

- Group 4: Perched Water

- Group 5: Snake River Plain Aquifer

- Group 6: Buried Gas Cylinders

- Group 7: SFE-20 Hot Waste Tank System.

Data gaps and uncertainties associated with contaminant source estimates, the extent of contamination, potential releases from the tank farm soil, and site risk prevented the Agencies from reaching a final remedial decision on the former INTEC injection well, groundwater inside the INTEC security fence, and the tank farm soils. As a result, the Agencies created OU 3-14 to address the final action, while interim actions are being implemented for tank farm soil and groundwater under the OU 3-13 ROD, which was signed in October 1999 (DOE-ID 1999a). The interim actions are designed to control the principal threat wastes at the tank farm site due to direct radiation exposure and due to potential leaching and transport of contaminants to the perched water or the Snake River Plan Aquifer (SRPA). The interim actions will be in place until the final remedy for these sites is selected and implemented as part of the OU 3-14 RI/FS process.

2.1.2 Operable Unit 3-13 Perched Water Final Action

Perched water exists beneath the tank farm and is a pathway for contaminants to migrate to the SRPA (DOE-ID 1999a). The OU 3-13 perched water (Group 4) remediation goals are to (1) reduce recharge to the perched zones and (2) minimize the migration of contaminants to the SRPA so that SRPA groundwater outside of the current INTEC security fence meets applicable State of Idaho groundwater standards by 2095. The selected OU 3-13 perched water remedy is institutional controls with aquifer recharge controls and includes the following items:

- Implementing institutional controls that include limiting access to prevent perched water use and to prevent future unauthorized drilling into or through the perched zone.

- Controlling surface water recharge to perched water. Infiltration controls are summarized in DOE-ID (2003a). The former INTEC percolation ponds were removed from service and replaced with new percolation ponds 2 miles west of INTEC on August 26, 2002. Additional infiltration controls include minimizing lawn irrigation at INTEC and minimizing steam condensate discharges to ground in 2003 and 2004. On December 4, 2004, the treated wastewater effluent was redirected to the service waste pipeline that flows to the new percolation ponds, and the infiltration trenches at the Sewage Treatment Plant (sewage treatment lagoons) and infiltration galleries were decommissioned and backfilled. The Tank Farm Interim Action (TFIA) included upgrades to surface water drainage systems. Several leaks in underground water lines have been discovered and repaired. Additional infiltration controls, if necessary, may include lining the adjacent reach of the Big Lost River, which was dry between 2000 to 2005.

- Measuring moisture content and contaminant of concern (COC) concentrations in the perched water to determine if water contents and contaminant fluxes are decreasing as predicted and to verify the OU 3-13 vadose zone model.

2.1.3 Operable Unit 3-13 Interim Action for the Snake River Plain Aquifer

The human health threat posed by the contaminated SRPA is exposure to radionuclides via ingestion by a hypothetical future resident. The Agencies selected an interim action for the SRPA. While the remedy selection for contaminated SRPA groundwater outside the INTEC security fence is final, the final remedy for the contaminated portion of the SRPA inside the fence was deferred to OU 3-14. As a result of dividing the SRPA groundwater contaminant plume associated with INTEC operations into two zones, the remedial action is classified as an interim action (DOE-ID 1999a). The OU 3-13 remediation goals for the SRPA outside of the current INTEC security fence are to (1) prevent current on-Site workers and nonworkers from ingesting contaminated drinking water above the applicable State of Idaho groundwater standards or risk-based groundwater concentration during the institutional control period and (2) achieve the applicable State of Idaho groundwater standards or risk-based groundwater concentrations in the SRPA plume south of the INTEC security fence by the year 2095. The selected OU 3-13 SRPA interim action, for contaminated portions of the SRPA both inside and outside the INTEC security fence, is institutional controls with monitoring and contingent remediation. This interim action consists of three components:

- Existing and additional institutional controls over the area of the SRPA that exceeds the maximum contaminant levels (MCLs) for H-3, I-129, and Sr-90 to prevent current and future groundwater use until drinking water standards are met.

- Groundwater monitoring to determine if specific SRPA groundwater contaminant concentrations exceed their action levels. If action levels are exceeded, determine if the impacted portion of the SRPA is capable of producing more than 0.5 gpm, which is considered the minimum drinking water yield necessary for the aquifer to serve as a drinking water supply. If both of these conditions are met, conduct treatability studies.

- Implementing contingent pump and treat remediation if treatability studies indicate sufficient quantities of COCs and contaminated groundwater can be extracted selectively and treated cost-effectively to meet the MCLs outside the INTEC security fence by 2095 (DOE-ID 1999a).

2.1.4 Operable Unit 3-13 Tank Farm Soils Interim Action

2.1.4.1 Remedy Components. The principal threats posed by tank farm soils are direct radiation exposure to workers or the public and the potential leaching and transport of contaminants to perched water or the SRPA. The major components of the remedy for the Tank Farm (soils) Interim Action (Tank Farm Soils, Group 1) (DOE-ID 1999a) are

- Restrict access to soils to control exposure to workers and prevent exposure to the public

- Reduce precipitation infiltration by 80% of the average annual precipitation at the site by grading and surface-sealing the tank farm soils

- Use surface water run-on diversion channels to accommodate a one-in-25-year, 24-hour storm event

- Improve exterior building drainage to direct water away from the contaminated areas.

The interim action specified for tank farm soil consists of institutional controls with surface water control to reduce surface water infiltration into tank farm soil until OU 3-14 remedial action begins.

2.1.4.2 Agreement to Resolve Dispute. On December 4, 2002, the EPA issued a Notice of Violation (NOV) for a dispute raised under the FFA/CO for WAG 3 (Kreizenbeck 2002). The NOV alleged that violations were caused by the failure of DOE Idaho to complete work as required under the Remedial Design/Remedial Action Work Plan for Group 1, Tank Farm Interim Action (DOE-ID 2000a). On February 21, 2003, the Agencies agreed to resolve the dispute.

In the Agreement to Resolve Dispute (ARD) (DOE 2003), DOE Idaho agreed to meet the intent of the TFIA by completing two phases. Phase 1 of the interim action was completed before September 30, 2003, and included the following:

- Grading and lining with concrete all existing storm water collection ditches around the tank farm and out to the discharge point.
- Replacing existing culverts around the tank farm and out to the discharge point with larger culverts to accommodate the expected increase in storm water flow.
- Constructing a lift station at the intersection of Beech Street and Olive Avenue to pump storm water to a location where the water will drain freely to the discharge point.
- Constructing concrete headwalls and endwalls as necessary throughout the lined drainage system.
- Constructing a lined evaporation pond to collect storm water run-off from the tank farm and other INTEC areas. All drainage ditches within the scope of this project were routed to this basin.
- Constructing two concrete-lined ditches within the tank farm to collect and direct precipitation run-off to the surrounding storm water collection system.
- Constructing a new fence around the evaporation pond.

Phase 2 of the TFIA was completed by September 30, 2004, and required DOE Idaho to place an infiltration barrier (asphalt) over the affected areas of the three principal soil contamination sites (CPP-28, -31, and -79). The purpose of Phase 2 was to meet the intent of the interim action, which is to reduce precipitation infiltration.

In the ARD, DOE Idaho also agreed to revise the data quality objectives (DQOs) as a modification to the existing *Operable Unit 3-14 Tank Farm Soil and Groundwater Phase 1 Remedial Investigation/Feasibility Study Work Plan* (DOE-ID 2000b). The revised RI/FS Work Plan (DOE-ID 2004a) superseded the December 2000 Work Plan and the 1999 Scope of Work document (DOE-ID 1999b). In the ARD, the Agencies agreed to a planned date of December 31, 2006, for completion of an early OU 3-14 ROD. An evaluation of the feasibility of accelerating the ROD for tank farm soils and expediting a phased implementation of the permanent remedy was presented in Appendix E of the Work Plan. The Agencies agreed to refine the planned date for the OU 3-14 ROD after the revised DQOs were established (Section 3.3.1 of the ARD [DOE 2003]).

DOE Idaho also agreed in the ARD to separate the nontank-farm soil components from the OU 3-14 RI/FS (the former INTEC injection well [CPP-23] and three No Action sites [CPP-61, CPP-81, and CPP-82]) and prepare a draft Explanation of Significant Differences (ESD) to the OU 3-13 ROD to address these components. The ESD, which was signed by the Agencies in 2004 (DOE-ID 2004b), transferred the injection well and three No Action sites back to OU 3-13 and finalized the No Action decision for these sites.

The ARD also states, “The Agencies agree to work collaboratively to expedite a phased implementation of the tank farm soil permanent remedy. The sequencing of tank closures and the schedule for tank farm soil remediation will be integrated to occur in stages” (DOE 2003). Information from RCRA tank closures; INTEC waste operations; and deactivation, decontamination, and decommissioning of tank farm infrastructure was included in the revised RI/FS Work Plan and will be in the OU 3-14 FS in order to integrate the OU 3-14 remedy selection and implementation with these other tank farm activities.

2.2 Regulatory Background of the Tank Farm Facility

The hazardous components of wastes stored at the tank farm are regulated through the DEQ. The tank farm is currently operating under HWMA/RCRA interim status as a hazardous waste management unit and is undergoing closure. As such, the requirements of 40 CFR 265, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” apply to tank closure. These requirements apply to the 11 underground tanks with a capacity of approximately 300,000 gal each, four tanks with a capacity of approximately 30,000 gal each, the tanks’ contents, and ancillary equipment and piping.

Under the terms of a *Consent Order to the Notice of Noncompliance* with the State of Idaho and EPA (DOE-ID 1992), DOE Idaho was required to permanently cease use of the tanks or bring the tanks into compliance with secondary containment requirements. The DOE Idaho decided to close the eleven 300,000-gal and four 30,000-gal underground tanks within the tank farm in part due to the impracticality of lifting the large tanks to install a liner underneath them. The second modification to the Consent Order (DOE-ID 1998) required DOE to cease use of the tanks in the pillar and panel vaults (Tanks WM-182, -183, -184, -185, and -186) by June 30, 2003, and the remaining tanks by December 31, 2012. Ceasing use of the tanks, as defined in the Consent Order, meant that DOE would empty the tanks down to their heels (i.e., the liquid level remaining in each tank was lowered to the greatest extent possible by the use of existing transfer equipment). DOE Idaho anticipates that the tank farm will continue to operate until 2012, while various parts of the facility are being closed.

The closure of the tanks is being performed in phases in accordance with a HWMA/RCRA closure plan that is prepared for each phase. The closure strategy being implemented provides for waste removal and system decontamination by a reiterative washing/flushing process. Performance of decontamination is demonstrated by sampling the final rinsate solutions from the decontamination efforts and comparing the resulting analytical data with risk-analysis-derived action levels. Risk-based action levels are developed by defining the acceptable excess cancer risk and hazard quotient thresholds and calculating corresponding action levels based upon these risk and hazard thresholds. The excess cancer risk and hazard quotients are calculated for appropriate facility-specific exposure pathways and COCs based upon the developed action levels. Figure 2-1 depicts the status of the 300,000-gal tanks as of December 31, 2005. The four 30,000-gal tanks have also been emptied and flushed. The final closure of the tank farm will be complete when all of the tanks and ancillary equipment have been closed, including performing any postclosure requirements. A decision to close the unit as a landfill or as a HWMA/RCRA clean closure will be determined during final closure (DOE-ID 2003b), currently scheduled to be completed by December 31, 2012.

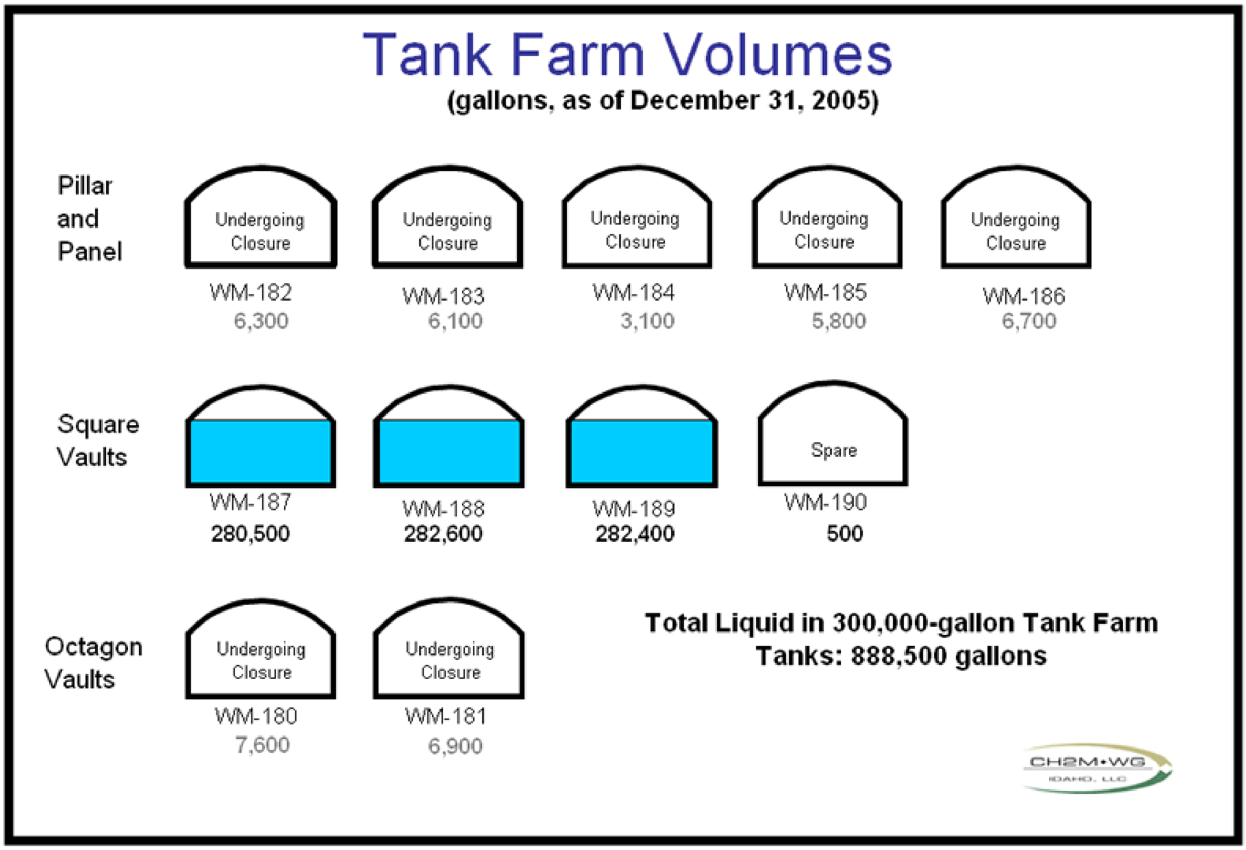

Figure 2-1. Tank farm volumes.

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3. INTEC BACKGROUND AND OPERATIONAL HISTORY

This section addresses INTEC's background, mission, and operational history as they pertain to the Tank Farm Facility and the tank farm soil contamination sites. It includes a discussion of the sources and compositions of the tank farm waste and the physical configuration of the tank farm as they relate to the soil contamination sites. Although none of the tanks in the tank farm have ever leaked, some of the ancillary piping, maintenance activities, sampling efforts, and other activities have released wastes that contaminated several sites in the tank farm.

3.1 INTEC Operational Summary

INTEC, originally called the CPP (later the Idaho CPP [ICPP]), began storing spent nuclear fuel (SNF) in 1952. SNF was brought to INTEC from a variety of reactors throughout the world and stored in underwater or dry storage facilities for an interim period. Beginning in 1953, some of the SNF was "reprocessed," a chemical treatment process that recovered enriched uranium and other products from the SNF for DOE and its predecessor organizations. SNF reprocessing and other INTEC support activities produced liquid radioactive waste that was stored in the tank farm. The INTEC tank farm has stored waste from SNF reprocessing operations and other incidental liquid waste streams from 1953 to the present. Figure 3-1 is an overview of historical INTEC operations, including SNF reprocessing and waste treatment, along with a map of INTEC showing major process locations.

The INTEC tank farm has a limited storage capacity and provided only interim storage for the large volume of liquid waste generated throughout the history of INTEC. Most of the liquid waste sent to the tank farm was removed and converted into a solid, granular form called calcine. Calcination consisted of spraying liquid wastes into a fluidized bed of thermally hot solids where the aqueous portion of the waste evaporated, leaving behind the dissolved constituents as the granular calcine material. From 1963 to 1981, liquid wastes were calcined in the Waste Calcining Facility (WCF). From 1982 to 2000, liquid wastes were calcined in the New Waste Calcining Facility (NWCF), which replaced the original WCF. The calcine is stored in six Calcined Solid Storage Facilities (CSSFs) located at INTEC.

In April 1992, DOE called for the shutdown of SNF reprocessing at INTEC (Ermold 1992). Since that time, no first-cycle liquid waste from SNF reprocessing (the primary source of tank farm waste) has been generated, although some waste has been generated by decontamination and incidental support activities. Calcination of the tank farm waste inventory continued through May 2000. DOE stopped calcining operations in compliance with the Third Modification to the Notice of Noncompliance Consent Order (DOE-ID 1999), which stipulated a June 1, 2000, shutdown of the calciner, followed by either permitted operation or facility closure. DOE is currently proceeding to close the NWCF. As a result, about 880,000 gal of waste (less than 10 volume percent of the amount sent to the tank farm over its history) remains in three of the 300,000-gal tanks today.

Although the tank farm tanks have never leaked, the terms of a 1992 Consent Order (DOE-ID 1992) and subsequent modifications required DOE either to stop using the 300,000-gal tanks or bring them into compliance with RCRA secondary containment requirements. Due to high radiation fields and limited access, the tanks cannot economically be retrofitted to meet RCRA requirements. Therefore, DOE has taken actions to empty and cease using the eleven 300,000-gal tanks. DOE has made the decision to treat the waste remaining in the tanks using steam reforming.

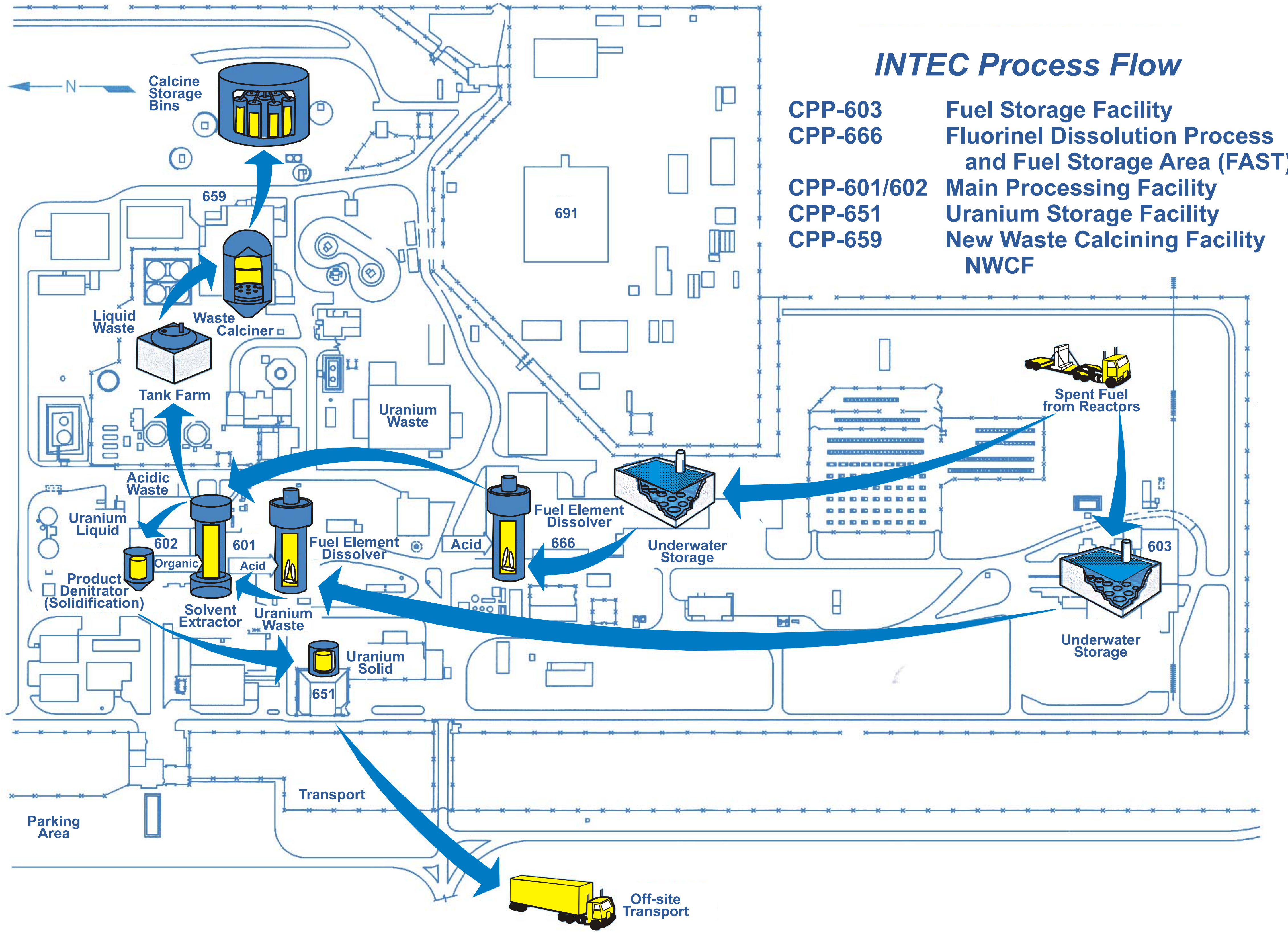

Figure 3-1. Simplified INTEC process schematic showing major historical INTEC operations and their locations.

3.2 Sources of Tank Farm Waste

The waste stored in the INTEC tank farm came from reprocessing SNF and related activities such as equipment decontamination, uranium purification, laboratory work, off-gas treatment, fuel receipt and storage, and waste calcination. There were five major sources of tank farm waste: first-cycle, second-cycle, and third-cycle raffinates from SNF reprocessing; process equipment waste (PEW) evaporator concentrate; and miscellaneous sources.

Reprocessing SNF generated the greatest volume of waste. Typically, SNF reprocessing included a three-step process. Each reprocessing step generated liquid waste, called raffinate. The first step (called first-cycle extraction) separated the uranium from the dissolved fuel cladding and radioactive material in the SNF. The second and third steps (called second- and third-cycle extraction) purified the uranium in preparation for off-Site shipment. Figure 3-2 is a simplified schematic of SNF reprocessing and the generation, storage, and calcination of first-, second-, and third-cycle raffinates.

The PEW evaporator system collected dilute radioactive wastes from a variety of sources, including equipment decontamination, cell floors, fuel storage basin water treatment systems, laboratories, and off-gas condensers. The evaporator concentrated the dilute waste and sent the concentrate (bottoms) to the tank farm for storage. Because of the relatively high concentration of sodium (Na) in the evaporator concentrate, that waste has been referred to as sodium-bearing waste (SBW). The vapors from the evaporator were condensed, sampled, and, for a number of years, discharged to the INTEC injection well via the service waste system. Recently, the evaporator condensate has been treated in the Liquid Effluent Treatment and Disposal (LET&D) facility and discharged to the atmosphere via the main stack. The tank farm wastes also included some "miscellaneous" wastes. These included steam-jet condensate, dilute wastes that exceeded the Waste Acceptance Criteria for the PEW evaporator, and nonradioactive waste from equipment testing and operator training. These five sources compose the bulk of the tank farm waste. In order to understand the types of waste that were inadvertently released and contaminated the tank farm soils, a detailed description of these wastes and other wastes and the processes that generated them is given in Sections 3.2.1 through 3.2.5.

3.2.1 First-Cycle Raffinate

The first step, or cycle, in reprocessing SNF typically began by dissolving SNF in acid to create an aqueous solution containing dissolved fuel cladding, radioactive fission and activation products, and uranium. The first-cycle uranium extraction process separated the uranium in the dissolver product solution from the dissolved fuel cladding and radioactive contaminants using a liquid extraction system. The uranium extraction system mixed the aqueous dissolver product with an immiscible organic (solvent) solution. By controlling the chemical makeup of the solutions, the uranium was extracted from the aqueous phase into the organic phase, leaving the bulk of the fission products in the aqueous solution. The uranium-bearing organic solution was separated from the fission-product-bearing aqueous solution and mixed with a second aqueous stream. By controlling the chemical makeup of the aqueous solution, the uranium was stripped from the organic solution into the second aqueous solution. The net result was two aqueous solutions, one with the bulk of the fission products (which became first-cycle raffinate) and one with the recovered uranium product. The stripped organic solution was recycled and reused. The original first-cycle process used hexone (methyl isobutyl ketone) as the organic solution. After a few years, the process was changed and thereafter a solution of approximately 5% tributyl phosphate (TBP) in dodecane (refined kerosene) was normally used as the organic extractant solution.

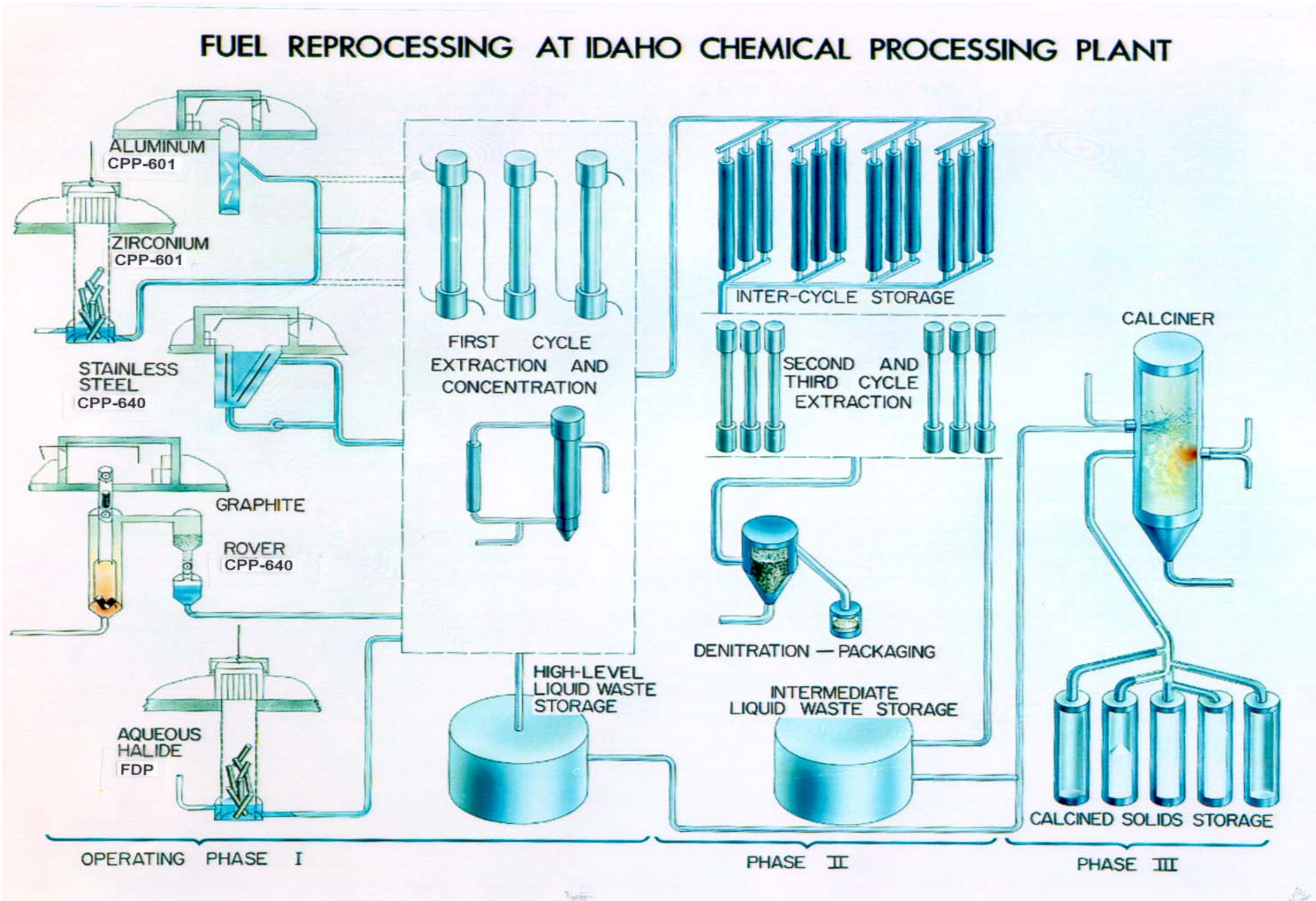

Figure 3-2. Fuel reprocessing, waste generation, and waste treatment processes at INTEC.

The first-cycle extraction product contained virtually all (99.99%) of the uranium that was originally in the SNF. The waste stream (first-cycle raffinate) contained the dissolved fuel cladding and the bulk (99.99%) of the fission products originally in the SNF. As a result, the radioactivity of first-cycle raffinate was significantly higher than that of any other tank farm waste. Historically, first-cycle raffinate was the largest single source of the waste in the INTEC tank farm and contained the bulk of the radioactivity (Loos 2004).

The original INTEC waste handling system segregated first-cycle waste from other liquid wastes. The tank farm included two basic tank designs. One was a simple, vented storage tank. The second tank design was more complex and included cooling coils in the tanks and off-gas condensers on the off-gas lines. First-cycle waste was stored in tanks equipped with cooling coils to remove the heat generated by radionuclide decay. This maintained the waste and tank within design temperature constraints.

The original SNF reprocessing design was based on aluminum (Al) -clad fuel. With time, the mission of INTEC expanded and the plant was modified to reprocess a variety of fuels. These included zirconium (Zr) -clad, stainless-steel-clad, and graphite matrix fuels. The chemical composition of the first-cycle waste depended on the type of fuel (fuel cladding) processed and the chemicals used to reprocess the fuel. Al-clad fuel was dissolved in nitric acid and generated waste containing Al, nitrate, and hydrogen (acid) ions. Zr-clad fuel was dissolved in hydrofluoric acid and generated waste containing Zr, Al (added for fluoride complexing), nitrate, fluoride (F), and hydrogen (acid) ions. Aluminum- and zirconium-clad fuels were the most frequently reprocessed fuels and consequently produced the greatest volumes of waste. Smaller quantities of stainless-steel-clad fuel were also dissolved. The initial stainless-steel fuel dissolution process used a sulfuric/nitric acid system. Later, an electrolytically enhanced, nitric acid dissolution system was used for reprocessing most of the stainless-steel-clad fuels. The sulfuric acid process produced a dilute waste comprised of iron (Fe), chromium (Cr), nickel (Ni), sulfate, nitrate, and hydrogen (acid) ions. The electrolytic process produced a dilute waste comprised of Fe, Cr, Ni, nitrate, Al (from the first-cycle extraction system), and hydrogen (acid) ions. Graphite matrix fuels were processed by burning the graphite and dissolving the uranium-bearing ash in hydrofluoric acid. The graphite fuel waste was relatively dilute, consisting of F, Al (from complexing), nitrate, and hydrogen (acid) ions. Table 3-1 provides typical compositions of several major first-cycle raffinates as well as SBW. The differences in the major chemical constituents are shown in the table.

In addition to the major chemical constituents, first-cycle waste contained a variety of minor components from the use of catalysts, oxidants, neutron poisons, corrosion control, etc. First-cycle Al raffinate contained mercury (Hg), which was used as a catalyst in the Al-clad fuel dissolution process. First-cycle Zr raffinate contained boron (B), which was used as a neutron poison in the original Zr-clad fuel dissolution process. Some of the Zr waste contained cadmium (Cd), which was used as a neutron poison in the most recent Zr fuel dissolution process (fluorinel). The fluorinel fuel dissolution process was a relatively new process. Nonradioactive testing of the fluorinel facility began in 1985. Radioactive operations began in late 1986. This was after the contamination of the tank farm soils occurred. Therefore, the contaminated tank farm soils do not contain Cd. Some first-cycle wastes contained Cr, which was used as an oxidant in some fuel dissolution processes. The wastes also contained minor constituents of the fuel cladding materials, which included trace amounts of tin (Sn), Ni, and Cr. Chemically different first-cycle raffinates were typically stored in separate waste tanks. This avoided potential chemical reaction problems such as precipitate formation. It also allowed for separate calcination of the wastes where different flowsheets were required for chemically different wastes.

Table 3-1. Typical compositions of major tank farm wastes.

Species	Units	Aluminum	Zirconium	Fluorinel	Stainless Steel (Electrolytic)	Sodium-Bearing Waste
Acid (H^+)	Molar	0.81	1.40	1.50	2.2	1.28
Aluminum	Molar	1.51	0.68	0.43	0.2	0.57
Boron	Molar	—[a]	0.19	0.15	—	0.017
Cadmium	Molar	—	—	0.05	—	0.001
Chloride	Molar	—	—	0.001	—	0.03
Chromium	Molar	—	0.015	0.002	0.025	0.001
Fluoride	Molar	—	3.2	2.10	—	0.04
Iron	Molar	0.01	0.007	0.005	0.086	0.002
Mercury	Molar	0.02	—	—	—	.0013
Nickel	Molar	—	—	—	0.012	—
Nitrate	Molar	5.4	2.3	1.90	3.2	4.5
Potassium	Molar	—	0.003	0.005	—	0.17
Sodium	Molar	0.06	0.017	0.02	—	1.5
Tin	Molar	—	0.005	0.003	—	—
Zirconium	Molar	—	0.41	0.31	—	0.03
H-3	Ci/L	1.8E-02	2.1E-04	2.1E-04	3E-03	2.7E-05
Sr-90	Ci/L	1.1	0.843	0.843	0.39	0.039
Ru-106	Ci/L	0.37	0.007	0.007	0.18	3.1E-06
Cs-134	Ci/L	0.12	0.058	0.058	0.0045	2.7E-04
Cs-137	Ci/L	1.2	0.878	0.878	0.42	0.044
Ce-144	Ci/L	5.24	0.031	0.031	3.1	1.6E-06
Pu-238	Ci/L	0.001	0.01	0.01	3E-05	0.001

a. "—" indicates concentration is negligible.

3.2.2 Second- and Third-Cycle Raffinate

The second- and third-cycle portions of SNF reprocessing were uranium purification steps. Both processes used a liquid (aqueous/organic) extraction system similar to that of the first-cycle system. Both processes used hexone as the organic extractant. The second-cycle process purified the uranium product from the first-cycle extraction system and produced a purified aqueous uranium product and a waste stream (second-cycle raffinate) containing radioactive contamination. The third-cycle process was an additional purification step that provided further purification of the second-cycle uranium product. It produced a further purified uranium product and a waste stream (third-cycle raffinate) containing radioactive contamination. Originally, the purified aqueous uranium product from the third-cycle process was shipped off-Site, usually to the Oak Ridge National Laboratory (ORNL). Later, a plant modification provided a solidification process, the denitrator, to convert the aqueous uranium product into a solid granular form for shipment to ORNL.

Unlike the first-cycle waste, the composition of the second-/third-cycle wastes did not vary significantly with the type of fuel being processed. The chemicals unique to various first-cycle wastes, such as Zr, F, Cd, and Hg, were separated from the uranium product and went with the first-cycle raffinate. The second- and third-cycle wastes were primarily acidified aluminum nitrate, regardless of the type of fuel that was processed. The original SNF reprocessing system combined the second- and third-cycle wastes into a single waste stream for storage in the tank farm, due to their similarity in chemical and radionuclide content. Due to their relatively low radioactivity, the second- and third-cycle wastes were originally combined with the PEW evaporator concentrate and stored in tanks without cooling capability.

3.2.3 PEW Evaporator

The PEW evaporator is located in Building CPP-604 and was the second-largest source of waste to the tank farm. The tank farm had a limited capacity and was designed to store relatively small volumes of concentrated wastes from SNF reprocessing. However, SNF reprocessing and INTEC ancillary processes also generated large quantities of dilute wastes with low levels of radioactivity. The dilute wastes included equipment decontamination solution, laboratory wastes, off-gas condensate, and ion exchange regeneration solutions. The tank farm did not have sufficient capacity to store large volumes of dilute waste, but the dilute waste contained too much radioactivity for direct disposal to the environment. The PEW evaporator concentrated the dilute wastes and sent the concentrate to the tank farm for storage. Historically, the PEW evaporator received dilute solutions from INTEC facilities and (via tanker truck) from other INL Site facilities (Reactor Technology Complex [formerly Test Reactor Area], Test Area North, etc.).

The PEW evaporator concentrated dilute, low-activity waste by boiling the waste and condensing the vapors. The evaporator effectively split the waste into two streams. One stream was a small volume of concentrated liquid (sometimes called "bottoms"). The concentrate contained most of the chemical and radioactive constituents (such as Al, Zr, Cs-137, and Sr-90) that were originally in the dilute evaporator feed solution. Typically, the evaporator generated 1 to 2 gal of concentrate from every 100 gal of feed, concentrating the waste feed by a factor of 50 to 100. The activity of the concentrated evaporator bottoms was comparable to the second-/third-cycle raffinate. Because of the comparable activity level, the original plant design combined the PEW evaporator concentrate with the second-/third-cycle raffinate and stored it in tanks without cooling capability.

The chemical content of the combined PEW evaporator concentrate and second-/third-cycle raffinate was different than other waste types. The waste contained nitric acid, aluminum, and significant concentrations (1 to 2 molar) of sodium (Na), which led to its current name of SBW. The high sodium content was the result of activities and processes (decontamination, scrubbers, etc.) that used sodium-based chemicals such as sodium hydroxide and sodium carbonate. The typical composition of SBW is provided in Table 3-1.

The second evaporator waste stream was the condensed vapors, called "process condensate." Because most of the chemical and radioactive constituents in the PEW evaporator feed were nonvolatile, the evaporator condensate was relatively clean water and contained only trace quantities of most chemicals and radionuclides. Exceptions to this generalization included elements with radioactive isotopes such as tritium (H-3) and iodine (I-129 and I-131) that were present as volatile compounds and went with the process condensate instead of the bottoms. The volatility of such components made the PEW evaporator condensate the single largest historical source of radioactivity sent to the INTEC injection well. Leaks of evaporator condensate generated soil contamination sites CPP-58 (east and west). Although the CPP-58 leaks were relatively large in volume (a few thousand gallons), they contained very small amounts of activity compared to other tank farm releases because of the low activity of the evaporator condensate.

3.2.4 Miscellaneous Aqueous Wastes

In addition to the first-, second-, and third-cycle raffinates and the PEW evaporator concentrate, there were a few miscellaneous sources of waste to the tank farm. Most of the miscellaneous wastes were relatively small volumes of dilute solutions. The largest sources of miscellaneous wastes included steam condensate (from steam-powered jet pumps used to transfer wastes), tank vault water (surface water that seeped into the tank vaults), and dilute wastes that exceeded the PEW evaporator Waste Acceptance Criteria (such as too much chloride, fluoride, or radioactivity). The volume of miscellaneous waste that was generated varied over time, but it averaged about 10% of the total waste generated. Much of the miscellaneous waste, such as the steam condensate and surface water that seeped into tank vaults, was not (initially) radiologically contaminated. Efforts were made to minimize those wastes by installing airlifts instead of steam jets to transfer wastes, by installing impermeable membranes over the tank farm to reduce infiltration, and by sending tank vault water to the PEW evaporator for concentration instead of directly into the tanks. The radiologically contaminated miscellaneous wastes typically contained insignificant amounts of radioactivity (orders of magnitude less) compared to first-cycle raffinate.

3.2.5 Organic Wastes

Waste organic solutions were not disposed of in the INTEC tank farm. A separate waste disposal system existed for organic compounds generated by the three-cycle uranium extraction and purification process that used organic compounds to extract and purify uranium from aqueous feed streams. Although waste organic and aqueous solutions were separated, the mixing of the two solutions in the uranium extraction and purification processes provided a means by which aqueous wastes from the three-cycle uranium extraction and purification processes may have been contaminated with organic compounds. Hexone, which was used in the second- and third-cycle uranium purification processes, had a slight (about 2%) solubility in water and was likely present in the second- and third-cycle wastes when they were initially generated. The kerosene used in the first-cycle extraction system was insoluble in aqueous solutions.

Some of the miscellaneous wastes may have also been contaminated by organic compounds. The INTEC laboratories used small quantities (pints per year) of organic reagents in various laboratory procedures. Some of those organic compounds may have been soluble in aqueous solutions or otherwise contaminated aqueous radioactive wastes generated in the laboratories. Such wastes were sent to the PEW evaporator and concentrated. The concentrate was sent to the tank farm and was a potential source of organic contamination to the tank farm wastes.

Organic compounds were also occasionally used as complexing reagents in equipment decontamination procedures. Organics such as ethylenediaminetetraacetic acid (EDTA), tartaric acid, citric acid, and oxalic acid were used in decontamination solutions to complex cationic radionuclides. This prevented the radionuclides from adsorbing onto the metallic equipment surfaces and allowed the radioactive contamination to be removed from equipment. The spent decontamination solution was sent to the tank farm, typically via the PEW evaporator, and likely contained residual organic complexing reagents.

Although many aqueous wastes had the potential to contain organic compounds, historical sampling of tank farm wastes generally found no repeatable, detectable, specific, target volatile or semivolatile organic compounds (SVOCs)in the wastes. All types of tank farm wastes were sampled, including first-, second-, and third-cycle raffinates, PEW evaporator bottoms, and miscellaneous wastes. The waste analyses included tests for specific compounds likely to have been in the wastes (such as hexone and TBP) as well as constituents of regulatory concern. The laboratory detection limits typically ranged between 10 and 50 ppb. Laboratory tests and studies showed the waste storage and treatment conditions (primarily high nitric acid content and concentration by evaporation) destroyed or removed most of the organics that may have initially been in the wastes, thus they were not detected in the waste samples (Swenson 2005).

Waste analyses typically found small concentrations (typically less than 0.1 ppm) of tentatively identified SVOCs in the samples, but neither the compounds nor their source was identified. Sample analyses show the wastes have a total organic content of about 0.5 g/L, regardless of the type of waste. The species that compose the total organic carbon have not been identified. They may be residual organics from the decontamination solution complexing reagents (which would not be detected as volatile or semivolatile compounds), or they could be other materials such as radiation-induced degradation products.

Sample analyses have shown the tank farm wastes contain small amounts of total organic carbon. Detailed analyses have shown what the organic compounds are not, but, due to the nature of organic analyses, the exact nature of the organic compounds remains unknown. Concentrations of known organic compounds in tank farm soil are available for use in the baseline risk assessment.

3.3 Tank Farm Construction Summary

The tanks in the INTEC tank farm were constructed from 1951 through 1964. For most of the INTEC history, various reports included 19 tanks in the tank farm. They included eleven 300,000-gal tanks (WM-180 through WM-190); four 30,000-gal tanks (WM-103 through WM-106); and four 18,000-gal tanks (WM-100, WM-101, WM-102, and WL-101). Due to recent changes in the INTEC mission, the use of the 18,000-gal tanks has been changed, in both operational and regulatory aspects, from the tank farm to the PEW evaporator system. This report includes the 18,000-gal tanks because they were significant to some of the tank farm contamination sites. Wastes transferred from the 18,000-gal tanks to the 300,000-gal tanks were the source of the CPP-79 (deep) contamination. Figure 3-3 is an aerial-view schematic of the tank farm showing the location of the 19 waste tanks.

The original 19 tanks were constructed by a series of six major projects as follows: (1) WM-180, WM-181, and the four 18,000-gal tanks; (2) WM-182 through WM-184; (3) the four 30,000-gal tanks; (4) WM-185 and WM-186; (5) WM-187 and WM-188; and (6) WM-189 and WM-190. Each tank construction project also installed waste transfer piping, off-gas piping, condensers, utilities, etc. associated with the tanks. Because the tanks were constructed by different projects at different times, they differ (sometimes significantly) in design details. These differences reflect changes in the design firms, processing needs and related design parameters, and the incorporation of "lessons learned" from operational experience with earlier designs.

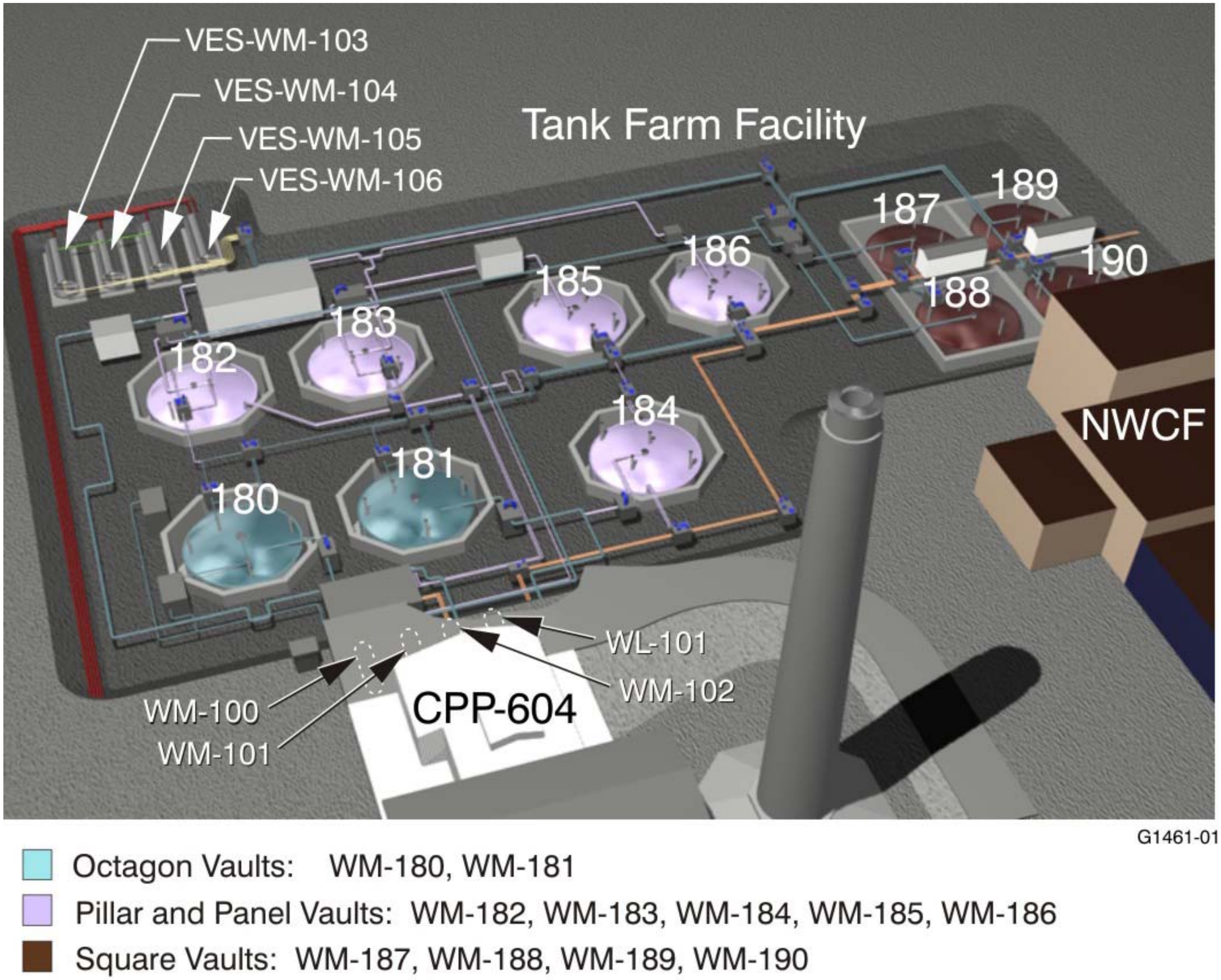

Figure 3-3. Aerial-view schematic of the tank farm looking northeast.

In addition to the six major projects that built the 19 tanks, there were numerous additional projects that repaired or replaced failed equipment, installed new equipment, or otherwise modified the tank farm. Some of the upgrade projects began work on the older tanks before the newest tanks were even built. There were also projects that modified equipment not directly connected to the tank farm (such as modifications to the PEW evaporator system in CPP-604), but whose construction was within the tank farm boundary. Such projects were sometimes instrumental in the generation, discovery, or removal of contaminated tank farm soil.

The tank farm upgrade projects included the addition of tank cooling systems, a tank vault sample system, access risers to buried valve boxes, valve boxes, an airlift transfer system, a tank-to-tank (and to the calciners) waste transfer system, the service waste diversion system, a tank-vault-to-PEW-evaporator transfer system, two tank farm surface liners, replacement and rerouting of waste transfer lines, secondary containment upgrades, utility line replacements, a siphon transfer system, replacement of the pressure relief valve discharge piping, valve upgrades, and several instrumentation upgrades. The instrumentation upgrades were made over time as advances in technology improved the precision and accuracy of various monitors. The instrumentation upgrades included the installation of an INTEC-unique radio frequency waste volume monitoring system, waste temperature monitoring enhancements, and leak detection system improvements (using pneumatic, conductance, and radiological monitors).

Nontank farm projects that affected the tank farm area included the installation of the waste solvent system and its connection to the PEW evaporator system, construction of a new PEW evaporator cell on the east side of CPP-604, construction of the WCF and the NWCF and their associated waste transfer lines into and out of the tank farm and CPP-604 (PEW evaporator), replacement of waste transfer lines from CPP-601 to the PEW evaporator, and the installation of the new PEW evaporator feed collection system (Tanks WL-132 and WL-133).

3.4 Physical Description of Tank Farm Systems

The design characteristics and historical use of the 19 tank farm storage tanks are presented in this section. The tanks include

- Eleven tanks with a capacity of approximately 300,000 gal each (WM-180 through WM-190)
- Four tanks with a capacity of about 31,000 gal each (WM-103 through WM-106)
- Four tanks with a capacity of about 18,000 gal each (WM-100 through WM-102 and WL-101).

3.4.1 300,000-Gallon Tanks

The eleven 300,000-gal tanks are similar in design. Each is a right cylinder in a vertical orientation with a flat bottom and a domed roof. Each tank has a diameter of 50 ft. Tanks WM-180 and WM-181 have a sidewall height (to the spring line) of 23 ft and a nominal capacity of 318,000 gal (though they are referred to as 300,000-gal tanks for simplicity). They are constructed of Type 347 stainless steel. Tanks WM-182 through WM-190 have a sidewall height (to the spring line) of 21 ft and a nominal capacity of 300,000 gal. They are constructed of Type 304L stainless steel. Each 300,000-gal tank is contained in an unlined, underground, concrete vault. The vault floors are located 41 to 49 ft below grade. Although there are differences among the tanks and vaults, a typical 300,000-gal tank and its vault are shown in Figure 3-4. Table 3-2 summarizes the main design characteristics and historical usage of the 300,000-gal tanks.

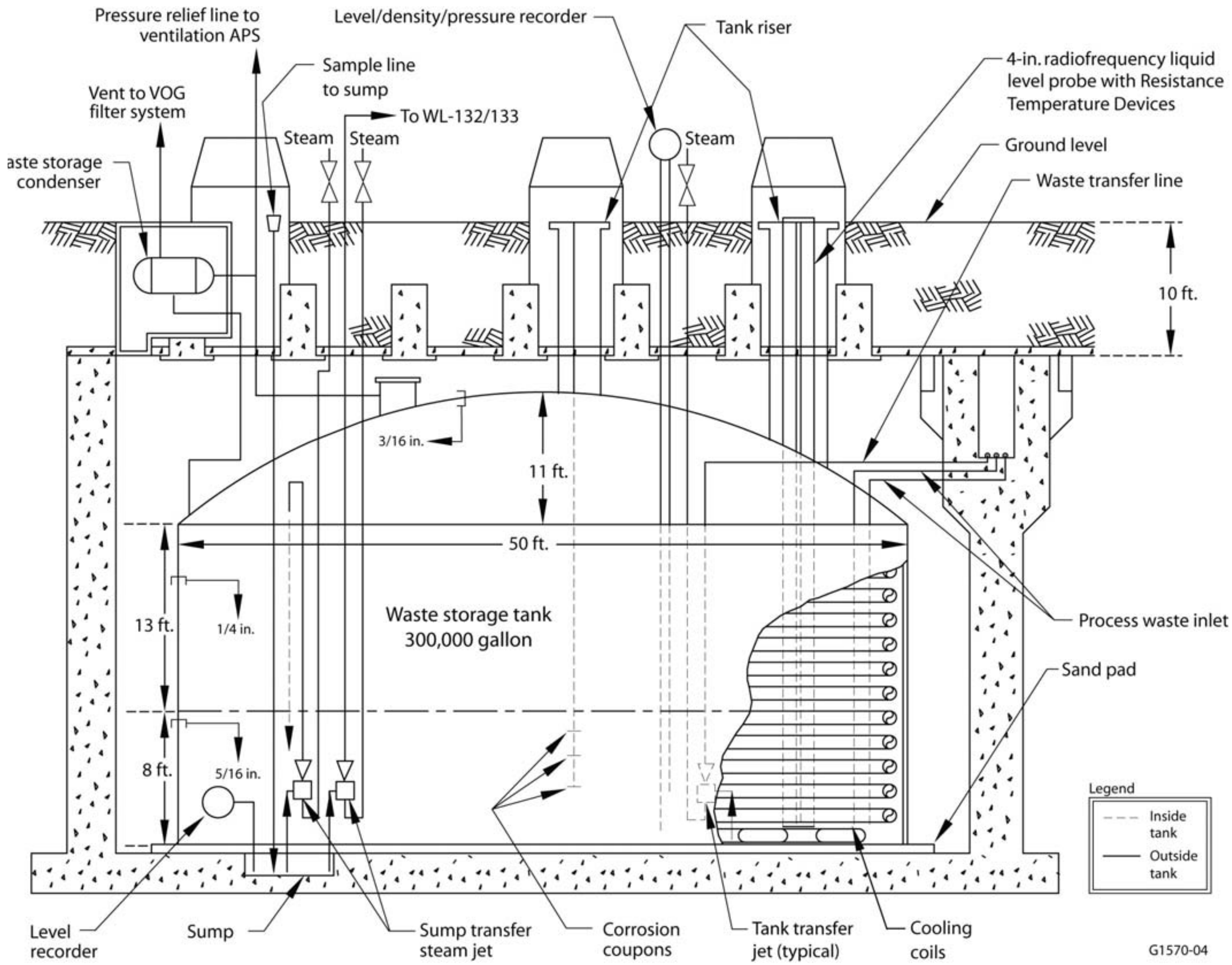

Figure 3-4. Schematic of a 300,000-gal waste tank showing typical tank and vault components.

Table 3-2. Summary of 300,000-gal waste tank design information.

Design	WM-180	WM-181	WM-182	WM-183	WM-184	WM-185	WM-186	WM-187	WM-188	WM-189	WM-190
Organization	Foster-Wheeler	Foster-Wheeler	Blaw-Knox	Blaw-Knox	Blaw-Knox	Fluor Corp.	Fluor Corp.	Fluor Corp.	Fluor Corp.	Fluor Corp.	Fluor Corp.
Tank subcontractor	Chicago Bridge and Iron (CBI)	CBI	CBI	CBI	CBI	CBI	CBI	Hammond Iron	Hammond Iron	Industrial Contractors	Industrial Contractors
Years constructed	1951-1952	1951-1952	1954-1955	1954-1955	1954-1955	1957	1955-1957	1958-1959	1958-1959	1964	1964
Initial service date	1954	1953	1956	1958	1958	1959	1962	1959	1959	1966	Not applicable (spare)
Codes	Unknown	Unknown	API-12C	API-12C	API-12C	API-12C	API-12C	API-12C	API-12C	API-650	API-650
Cooling coils (yes/no)	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes
Tank diameter (ft)	50	50	50	50	50	50	50	50	50	50	50
Tank height to springline (ft)	23	23	21	21	21	21	21	21	21	21	21
Tank capacity (gal)	318,000	318,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Lower tank thickness (in.)	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125
Upper tank thickness (in.)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Type of stainless steel	347	347	304L	304L	304L	304L	304L	304L	304L	304L	304L
Number of waste transfer jets/airlifts	two jets	two jets	two jets	two jets	two jets	two jets	two jets	two jets	two jets	one jet one airlift	one jet one airlift
Type(s) of waste stored	First-cycle raffinate/SBW	SBW	First-cycle raffinate	First-cycle raffinate/ SBW	SBW	First-cycle raffinate/ SBW	First-cycle raffinate/ SBW	First-cycle raffinate/ SBW	First-cycle raffinate/ SBW	First-cycle raffinate/ SBW	Spare tank

In general, the tank farm stored two types of waste: one with high radionuclide activity (first-cycle raffinate) and one with relatively low radionuclide activity (second- and third-cycle raffinate and PEW evaporator concentrate). The high-activity waste was self-heating due to the decay of radionuclides and was stored in tanks equipped with cooling coils and off-gas condensers that maintained the waste within design temperature constraints. The lower-activity waste did not require cooling and was normally stored in tanks that were not equipped with cooling coils or off-gas condensers. Tanks WM-181, WM-184, and WM-186 do not have cooling coils or off-gas condensers; the other eight 300,000-gal tanks have cooling coils and off-gas condensers. Figure 3-5 is a photograph of the interior of WM-185 during its construction and shows some of the features of a typical 300,000-gal tank, including the cooling coils, instrument probes, flat floor, and domed roof.

For most of the tank farm history, each tank had two means to transfer waste to other tanks or the calcination facilities. WM-180 through WM-188 had two steam-powered jet pumps to transfer waste. WM-189 and WM-190 had one steam-powered jet pump and an airlift to transfer waste. The airlifts were installed in the last two tanks as an alternate method to transfer waste that minimized waste generation by eliminating the steam condensate associated with the operation of steam jets.

Each tank was equipped with a variety of instruments that were upgraded over time. The instrumentation measured parameters including waste level/volume, temperature, density, and tank head-space pressure. The tanks were equipped with various numbers and sizes of "risers," which were pipes connected to the tank roof that extended up to grade level, providing access to the inside of the tank. The risers were used to obtain liquid waste samples, install and retrieve corrosion-monitoring sample coupons, install tank inspection devices (cameras), install instrumentation upgrades, etc.

Each tank was connected to two off-gas systems. The normally used system included stainless-steel piping that routed gases from the tanks to vessel off-gas treatment (filtration) systems located in Buildings CPP-604 and CPP-649. Each tank was also connected to a pressure and vacuum relief system. That system included a combination pressure/vacuum relief valve and a carbon-steel pressure relief line that originally vented to the main INTEC exhaust stack. The carbon-steel line had a low-point condensate drain line that was modified over time. The modifications created a configuration in which contaminated, acidic waste backed up into the carbon-steel line. The acidic waste corroded the carbon-steel line and leaked to the soil, contaminating Sites CPP-27 and CPP-33. The pressure relief line was rerouted to the CPP-604 ventilation exhaust system. The carbon-steel portion of the system was replaced with a stainless-steel line in the 1990s.

The 300,000-gal tanks were contained in underground concrete vaults. The concrete vault designs varied among the tanks, reflecting differences among the five 300,000-gal tank construction projects. In general, there were three basic vault designs as described below:

- <u>Monolithic octagon</u>. This design was used by the first tank construction project that built two tanks (WM-180 and -181). These two vaults were constructed in 1951 to 1952. They are poured-in-place, reinforced, concreted monoliths with flat floors. Their tanks are bolted to the vault floor. Figure 3-6 is a photograph showing the construction of the WM-180 vault. Tank WM-180 is also visible inside the vault.

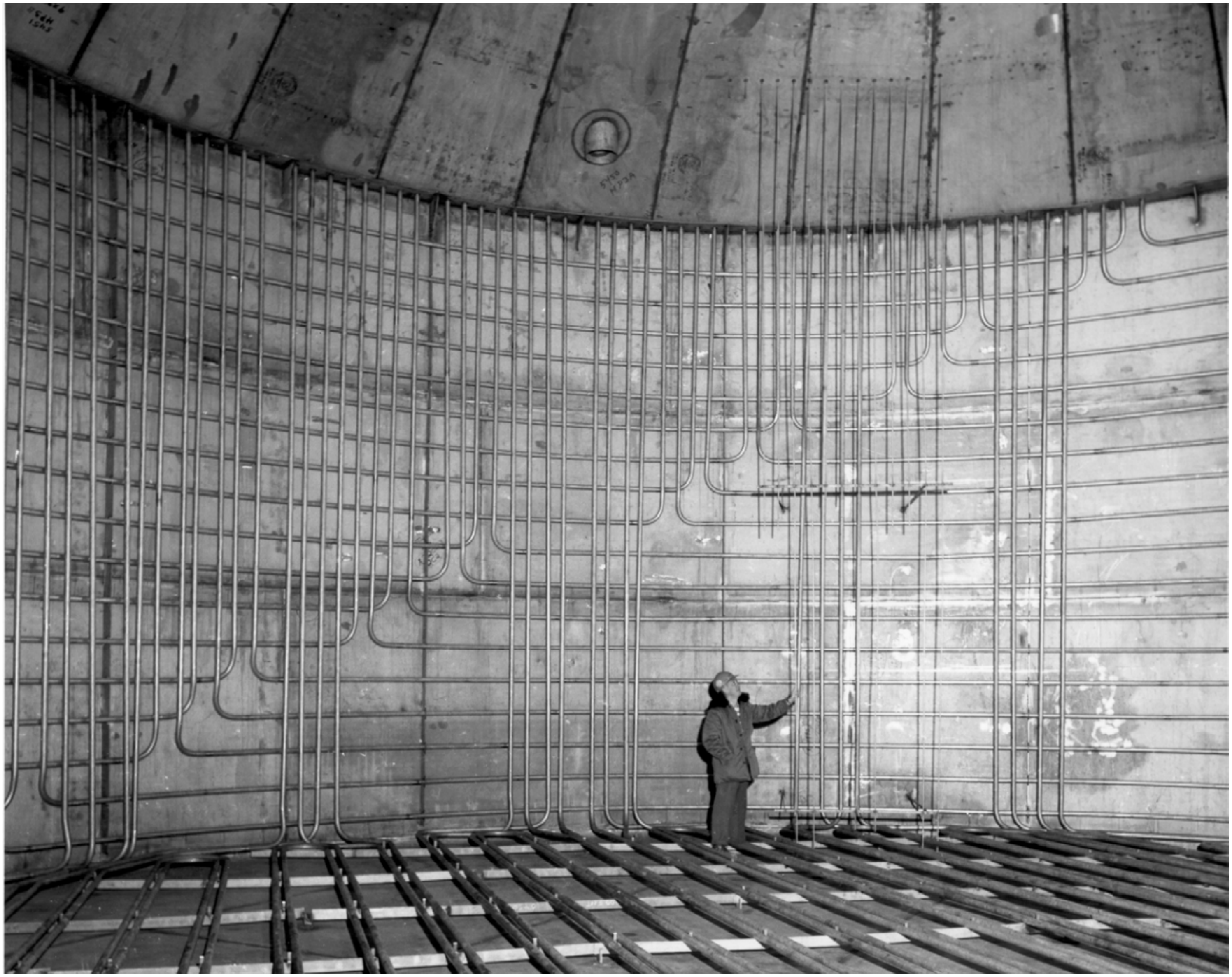

Figure 3-5. Interior of a typical 300,000-gal tank (WM-185) showing cooling coils and pneumatic instrument probes. (58-978)

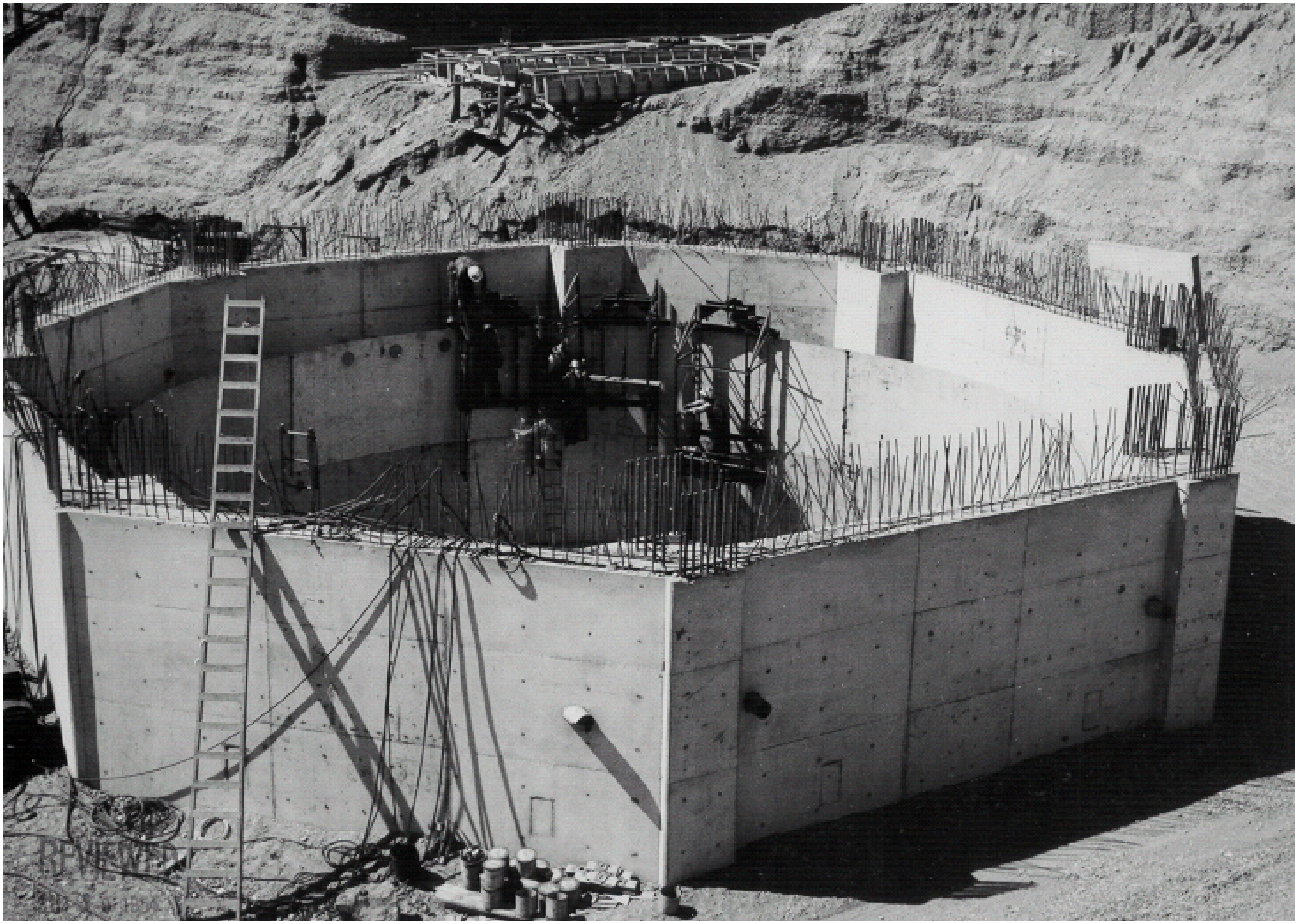

Figure 3-6. Construction of monolithic octagonal vault for WM-180. (2940)

- Pillar and panel octagon. This basic design was used by two projects that built five tanks (WM-182 through WM-186). The vaults for WM-182 through WM-184 were constructed in 1954 to 1955; the vaults for WM-185 and WM-186 were built in 1957 to 1958. The pillar-and-panel vaults are octagonal in shape. The walls were constructed of prefabricated, reinforced concrete pillars and wall panels. The roofs were made with precast concrete beams and poured-in-place ceiling panels. Though similar in concept, the two pillar-and-panel designs varied in many details, such as the joint between the ring beams and roof beams. The pillar-and-panel design is considered the seismically weakest of the three basic vault designs. Therefore, tanks with this design were emptied first in accordance with the Consent Order (DOE-ID 1992) and its modifications. The vault floors are conical-shaped, sloping downward from a high point in the center of the vault to facilitate liquid drainage to a collection system. The sloping portion of the floor is covered with a sand pad, held in place by a 6-in. concrete curb. The tanks rest upon the sand pad and are not anchored to the floor. Figure 3-7 is a schematic showing a tank resting upon a sand pad in a typical vault. Figure 3-8 is a construction photograph that shows the pillars and panels of the walls being set in place for the WM-183 vault. Figure 3-9 is a construction photograph of WM-185 that shows the dome of the tank inside the vault and the roof beams on top of the vault walls.

- Monolithic square. This design was used for two different projects (WM-187 through WM-190). These vaults are reinforced, poured-in-place, monoliths. The four individual vaults are square and arranged in a 2 × 2 pattern that forms a single, large, square vault complex. The vaults for WM-187 and WM-188 were constructed in 1958 to 1959 in a side-by-side pattern. The vaults for WM-189 and WM-190 were constructed in 1963 to 1964 in a side-by-side pattern that shared a wall with the WM-187/-188 vaults. This created a large square vault subdivided into four smaller square vaults. The square vaults have a conical-shaped, sloping floor covered by a sand pad, similar to that of the pillar-and-panel vaults. Figure 3-10 is a construction photograph showing the two adjacent square vaults for WM-189 and WM-190.

All the tank vaults have leak detection and liquid removal systems. These consist of one or more liquid collection and monitoring sumps and a steam-jet-powered liquid transfer system. Tanks WM-180 and WM-181 each have one 120-gal leak collection sump, WM-182 through WM-188 each have two 7.5-gal leak collection sumps, and WM-189 and WM-190 each have two 22.5-gal leak collection sumps.

Originally, liquid in the leak collection sumps could be transferred only into one of the 300,000-gal tanks. This proved to be a problem because some of the panel/beam joints in some of the roofs of the tank vaults leaked, allowing surface water (rainfall and snowmelt) to accumulate in the vaults. Transferring the vault water into the tanks diluted the waste (which hindered waste calcination) and used part of the limited tank farm storage capacity. This was partially resolved with the WM-189 and WM-190 vault design which included one large (1,000-gal) sump in each of those two vaults that was designed to collect and remove surface water infiltration. In the early 1970s, a temporary, aboveground piping system was used to transfer tank vault water to the PEW evaporator from several of the tank vaults. Drips from connections in this temporary piping caused soil contamination site CPP-32W.

The vault water problem was finally resolved with two changes made by a 1977 upgrade project: (1) the installation of an impermeable membrane over the entire area occupied by the 300,000-gal tanks to prevent surface water from seeping into the vaults and (2) the installation of a permanent piping system to transfer water from the tank vaults to the PEW evaporator system. Although there are no data that show the impermeable membrane reduced the seepage into the tank vaults, the new system to transfer vault water to the PEW evaporator effectively resolved the problem of water in the tank vaults.

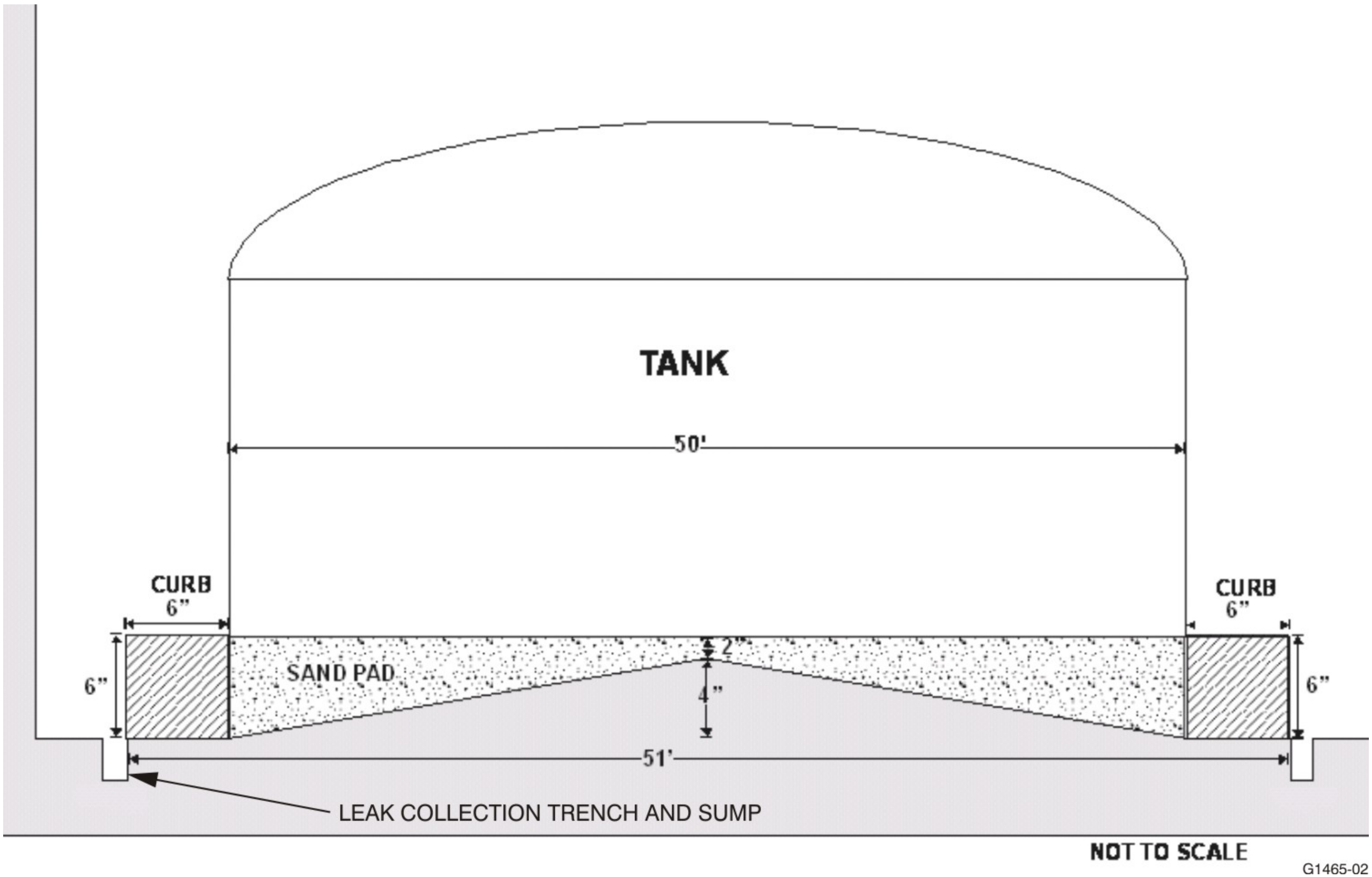

Figure 3-7. Schematic of a typical 300,000-gal tank (WM-182 through WM-190) resting upon a sand pad.

Figure 3-8. Construction of the pillar-and-panel vault for WM-183. (13450)

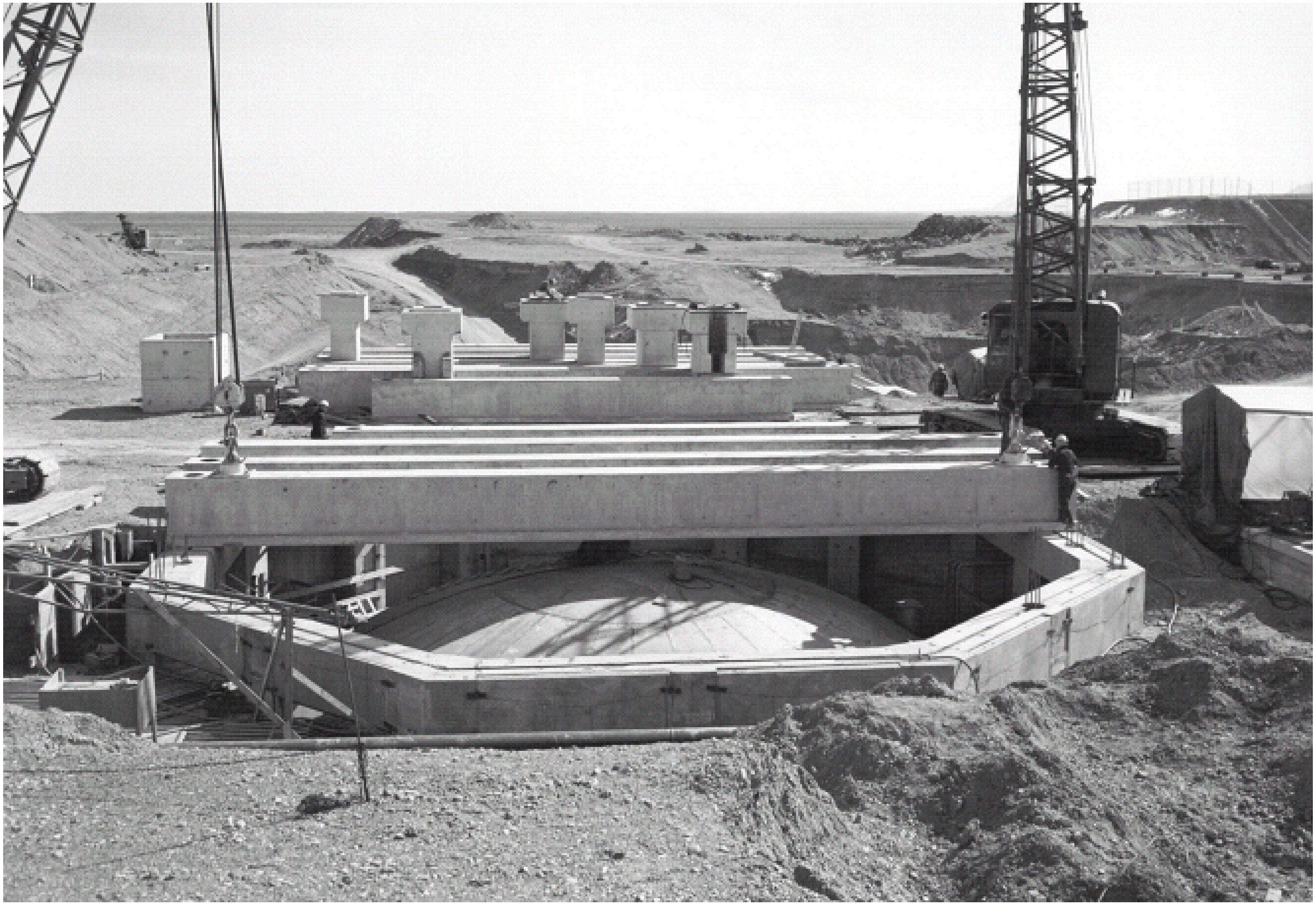

Figure 3-9. Setting roof beams in place on the WM-185 vault (the dome of Tank WM-185 is visible within the vault). (58-1221)